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UNHOLTZ-DICKIE CORPORATION
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# VIBRATION TESTING SYSTEM

TA250-102

## OPERATING AND MAINTENANCE MANUAL

MP MASTER
MA34568

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CAUTION: The console is equipped with door interlock switches to shut down the system if the door is opened. However, even with the system shut down, input power line voltages may be exposed at some points within the console. Always turn off all power at customer installed disconnects before opening console doors.

Use of customer installed circuit breaker with heavy duty undervoltage release can further reduce this hazard. See following pages.

# Operation of Customer Power Disconnect by Power Amplifier Door Switches

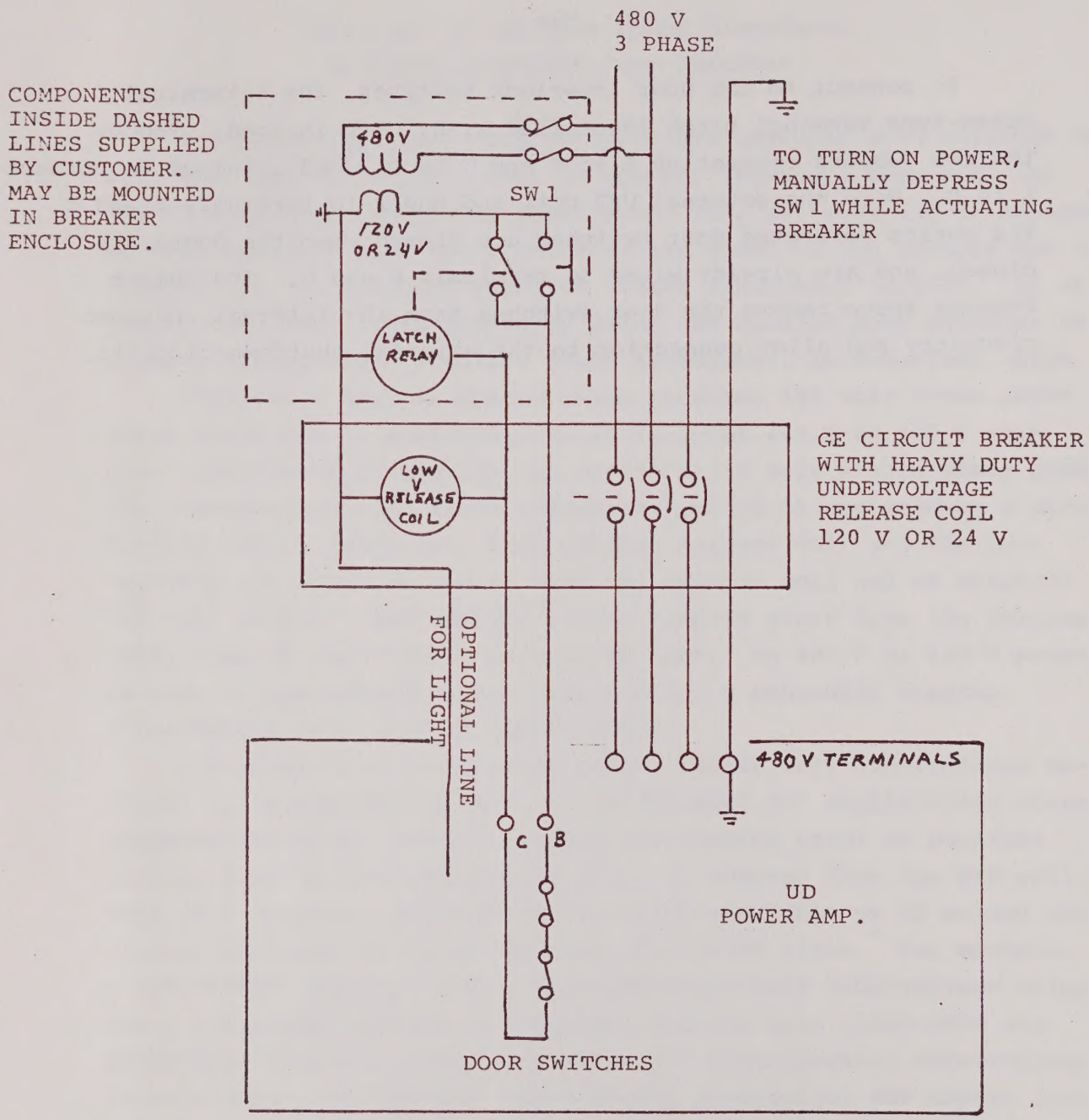
The power amplifier console doors are equipped with switches to shut down the system if a door is opened. However, even with the system shut down, hazardous input power line voltages may be exposed at some points within the console unless power to the console has been shut off at the customer supplied "fused disconnect" switch. It is possible to avoid this hazard by using the console door switches to operate the customer supplied power disconnect, as described below.

Consider a typical system which requires 480 volt three phase power input and is equipped with an internal 480 V to 120 V step down transformer to provide the system's 120 volt single phase power. The customer supplied fused disconnect switch is replaced by a circuit breaker with a Heavy-Duty Undervoltage Release coil and the door switches are wired in series with the release coil and an external 120 volt source. Now opening a door removes power from the release coil, causing the circuit breaker to open. No 480 V or 120 V power is left in the console. See figure 1 for a schematic diagram illustrating this type of installation.

A General Electric breaker with a "Heavy-Duty Undervoltage Release" is recommended because it is designed for applications where repeated UVR trips are anticipated and breaker reset or possible contact kiss is prevented while power is removed from the UVR coil. This is a factory installed modification available on GE molded case circuit breakers in the E150, J600, and K1200 lines.* For example, a TJK636500WL breaker with a TJXUVBRS Heavy-Duty Undervoltage Release has a 500 ampere ambient compensated thermal trip (1500-5000 amp adjustable instantaneous trip) and a 120 volt operated undervoltage release coil. The breaker has a 30,000 symmetrical RMS ampere interrupting rating in 480 volt service. Choose a breaker size appropriate for the particular system and power source.

* It is also available on the "Tri-Break" Model TB1, TB4, and TB6 integrally fused breakers which provide very high interrupting capability.

To connect to the door interlock switches, the 4 terminal, screw-type terminal block identified A, B, C, D is used. Remove the two jumpers connecting A to B and C to D. Add a jumper to connect A to D. Wire the external UVR coil and power to terminals B and C. The series connected door switches are closed when the doors are closed, and are already wired to terminals B and C. The jumper changes above remove the door switches from the internal shutdown circuitry and allow connection to the external shutdown circuits.


480 V
3 PHASE
COMPONENTS INSIDE DASHED LINES SUPPLIED BY CUSTOMER. MAY BE MOUNTED IN BREAKER ENCLOSURE.
480V
SW 1
120V OR 24V
LATCH RELAY
TO TURN ON POWER, MANUALLY DEPRESS SW 1 WHILE ACTUATING BREAKER
LOW V RELEASE COIL
GE CIRCUIT BREAKER WITH HEAVY DUTY UNDERVOLTAGE RELEASE COIL 120 V OR 24 V
OPTIONAL LINE FOR LIGHT
480 V TERMINALS
C
B
UD POWER AMP.
DOOR SWITCHES

OPENING DOOR SWITCH REMOVES UNDERVOLTAGE RELEASE COIL POWER CAUSING BREAKER TO OPEN. THIS REMOVES ALL POWER FROM P.A.

FIGURE 1

9/81

Section

# CONTENTS


A System Specifications

B System Data

C Description of System

- I Shaker
- II Other
- III Controls and Instruments
  - A. Oscillator
  - B. Servo Programmer
  - C. Vibration Meter
  - D. Optional Signal Conditioning Amplifier
- IV Power Amplifier
- V Description of accessories or features special to the system. (Omitted on Standard systems)
- VI Heat Exchanger
- VII CSTA

D Operating Instructions

- I To Start System
- II To Operate System
  - A. Manually Controlled
  - B. Automatically Controlled

E Operating Considerations

- I Calculation of Rated Acceleration
- II Operation with Reduced Field Power
- III Table Accelerometer Sensitivity Spot Check

F Maintenance, Disassembly instructions for shaker

G Shaker Parts List

H

I

J

K

L

M

N Fixture Design

O Trouble Shooting the System

P System Diagrams Drawing Numbers

Q System Performance Curve

R Accelerometer Manual

S Bulletins

T Drawings

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UNHOLTZ - DICKIE CORPORATION
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REDONDO BEACH, CA 90277

# WARRANTY

All products are warranted to be free of defects in material and workmanship for a period of one year from date of shipment. If the product is not installed, maintained and used in a normal manner in accordance with instructions and manuals, this warranty will not apply. Commercially available instruments and accessory items purchased and installed in the product will carry the original manufacturer's warranty.

This warranty is limited to repairing or replacing parts which have been returned and in our opinion are defective. Service required to correct defects in material or workmanship will be supplied without charges. The Buyer will pay all transportation and taxes incurred. This warranty does not cover any costs incurred by the Buyer as a result of purchase of UNHOLTZ-DICKIE CORP. equipment or any charges for the Buyer's labor for replacement, adjustment or repair unless authorized in advance in writing. We are not liable for consequential damages.

This warranty will not apply to any products which, in the opinion of UNHOLTZ-DICKIE CORP., have been subject to accident, misuse or neglect; altered or repaired with a substitute which might impair the product; or used outside of rated conditions. UNHOLTZ-DICKIE CORP. reserves the right to make improvements in its products including changes and additions without incurring obligations to incorporate such improvements in previous units.

This warranty is expressly in lieu of any and all other warranties or commitments, expressed or implied and any other obligations to the Buyer associated with the use of UNHOLTZ-DICKIE CORP. products.

UNHOLTZ-DICKIE CORPORATION

Test Equipment And Instrument Inspection

And

Shipping Instructions

1. Unpacking and Inspection

If the shipping carton is damaged, note on acceptance that it is received damaged and subject to claim when inspected. Ask that the carrier's agent be present when the instrument is unpacked and inspected for damage (scratches, dents, broken knobs, etc.). If the instrument is damaged or fails to meet specifications, notify the carrier and the Unholtz-Dickie Corp. immediately. Retain the shipping carton and the padding material for possible return for repair or further inspection by carrier. The purchaser and Unholtz-Dickie Corp. will arrange for the replacement and/or repair of the damaged item.

Refer to our separate warranty page for a statement of our warranty policy.

2. Storage and Shipment

Return Shipment Procedure: Please be sure the following instructions are observed if for any reason the item is being shipped back to Unholtz-Dickie for repair or replacement.

A. Packing: To protect valuable electronic equipment during storage or shipment, always use the best packaging methods available. Unholtz-Dickie can provide packing material such as that used for original factory packaging. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here are a few recommended packaging methods:

(1) Original - Place instrument in original container. Replace all packing pads and fillers in the exact position which they originally occupied. If original packing is no longer available, use 2 inch thick foam rubber padding.

(2) Rubberized Hair - Cover painted surfaces of instrument with protective wrapping paper or plastic bag. Pack instrument securely in strong corrugated container, double wall (350 lb/sq. in. minimum bursting test) with 2 inch rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and containers to ensure a snug fit.

(3) Excelsior - Cover painted surfaces of instrument with protective wrapping paper or plastic bag. Pack instrument in strong corrugated container, double wall (350 lb/sq. in. minimum bursting test) with a layer of excelsior about 6 inches thick packed firmly against all surfaces of the instrument.

B. Environment: Conditions during storage and shipment should normally be limited as follows:

(1) Minimum Temperature: -40°F. (-40°C)

(2) Maximum Temperature: 167°F. (+75°C)

(3) Maximum Average Humidity: Less than 70%

3. Systems shipped in winter are normally filled with antifreeze. Flush antifreeze out of the system before putting into service.

## A. SYSTEM SPECIFICATIONS

| | | | |
|---|---|---|---|
| Generated Force, continuous rating | Sine | 500 | lbs peak |
| | *Rand | | lbs RMS |
| Armature Assembly effective weight | | 5.3 | lbs Nom |
| Maximum Free table acceleration | | 92 | g |
| Shaker Stroke | | 1 | inches |
| Shaker Table suspension stiffness | | 225 | lbs/in. Nom |
| System Performance | See Curve # | 940213 | |
| Free table axial resonant frequency | | 4375 | Hz Nom |

Conversion Formulas for Vibration Measurements:

$$g\ (pk) = .0511\ f^2\ D(\text{in pk-pk})$$

$$D(\text{in pk-pk}) = \frac{19.56}{f^2}\ g\ (pk)$$

$$V(\text{in pk/sec}) = \frac{61.45}{f}\ g\ (pk)$$

$$D(\text{in pk-pk}) = \frac{0.3183}{f}\ V(\text{in pk/sec})$$

Where f = frequency (Hz or cycles per sec)
g = acceleration due to gravity (386 $in/sec^2$)
V = velocity (in/sec)
D = displacement (in pk-pk or double amplitude)

*Random rating with flat spectrum and load greater than _____.

## B. SYSTEM DATA

Vibration Testing System: No. TA 250-102

Shaker: Model No. T102 Serial No. 290

Power Amplifier: Model No. TA250A, S/N 332

Control Console: Model No. MA250-102, S/N 1070

OSP-4, S/N 383 { Automatic Shaker Control: Model No. _____ Serial No. _____
Oscillator: Model No. _____ Serial No. _____

Charge Amplifier: Model No. — Serial No. —

Input Power:

| Volts | Phase | Total System kVA | Total System Amps | |
|---|---|---|---|---|
| 115 | 1 | 1 | 8 | |
| 208 | 3 | 8 | 22 | Console |
| | | 1.3 | 3.4 | Blower |

Shaker:

Field Coil:

Nominal Current After Warmup 37 A ~~Upper~~ ~~A Lower~~

Resistance 70° F 0.81 ohm Upper 1.08 ohm Lower

Cooling: Air _____

Heat Exchanger _____

Raw Water 1 gpm, 40 to 85 psi, 85 °F Max.

Variable Degaussing Coil (Optional Accessory)
Optimum current setting — amp DC

Shaker (Continued):

Driver Coil:

Cooling: Air

Maximum current: 50 Amps $I_{collector}$

Table Accelerometer:

Mfr: UNHOLTZ-DICKIE

Model: 10B10 Serial No. 1849, 1850

Outline dimensions and table bolt pattern:

Refer to Bulletin attached

Amplifier:

Cooling:

✓ Air

Water, _____gpm_____to_____psi_____°F. Max.

## CAUTION

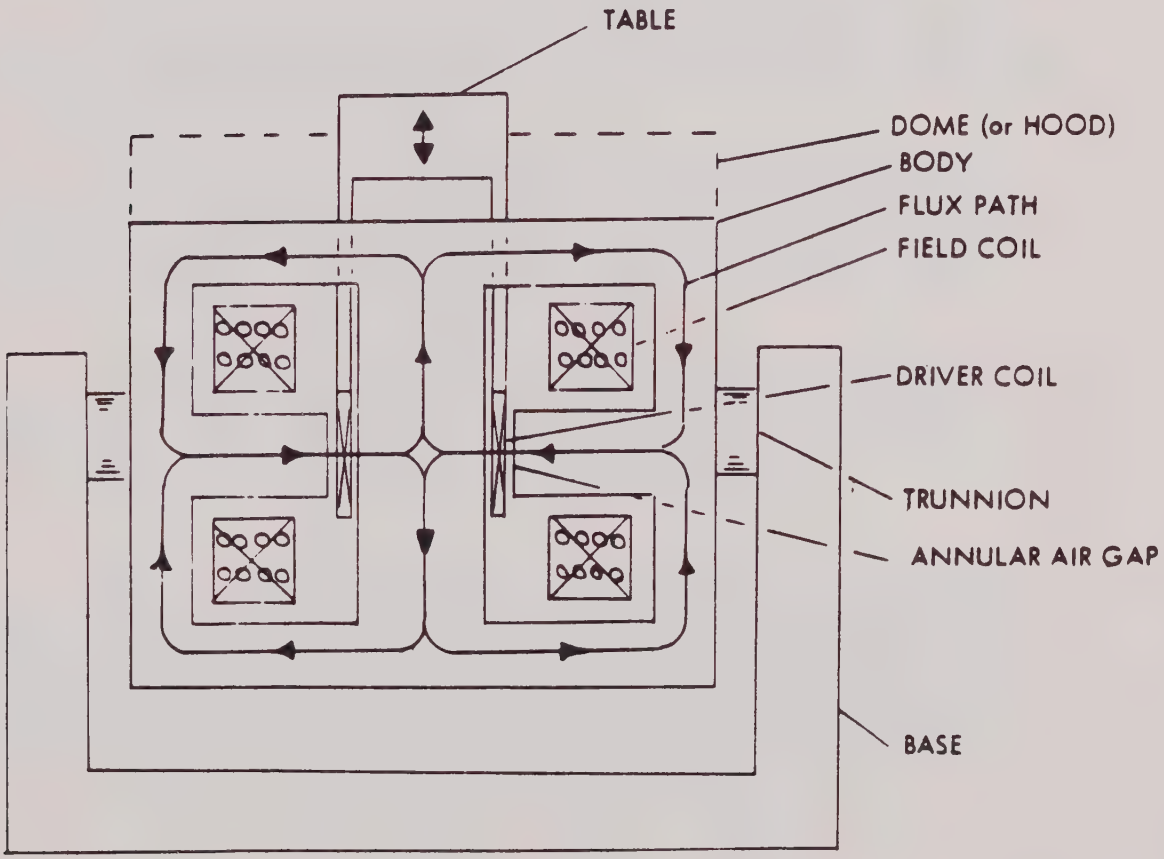
Vibration generating systems by design have a table which vibrates perpendicular to its surface. This table motion generates sound pressure levels, the intensity of which depends upon the operating conditions, the items attached to the table, etc. Operating personnel may be exposed to noise levels above accepted maxima, depending upon operating conditions which can be lowered to acceptable levels by the use of ear protectors, sound insulation or other means.

## C. DESCRIPTION OF SYSTEM

The Vibration System usually consists of three separate parts, the Shaker, the Control Console and the Electronic Power Amplifier. In some of the smaller systems the Power Amplifier is located within the Control Console leaving two separate parts.

1. Shaker

The Shaker is the heart of the system. It provides the vibrating table to which the items to be tested are attached. The principal parts of the Shaker are shown in the illustration.




SHAKER SCHEMATIC DIAGRAM

The water cooled field coils energize the Shaker body with flux paths as shown creating a high magnetic flux density in the annular air gap. The field coils are connected to a d-c power source. The armature assembly, consisting of the table and driver coil, is suspended from the Shaker body by the Unholtz-Dickie table suspension. When an alternating current is passed through the driver coil, an electrodynamic force is generated in the driver coil wires causing the table to move as indicated by the double ended arrow drawn on the table. The frequency of the alternating current determines the frequency of vibration in the table. The table motion depends on the magnitude of the generated force, the mass of the table and load attached to the table, the stiffness of the table suspension and other factors. The motion of the table is limited by the maximum stroke of the Shaker, the available voltage from the electronic Power Amplifier in the low frequencies and by the rated force or maximum acceleration in the higher frequencies.

The Shaker is trunnion mounted allowing it to be oriented for vertical or horizontal vibration or any position between these limits. In larger shaker models such as the Models 200 and 500, a resilient mounting is incorporated in the trunnion mount to isolate the vibration of the Shaker from the base and mounting floor.

The Shaker includes electrical switches which trip just prior to contacting the table displacement limiting snubbers. In addition, a thermostate switch is located on the field coil which automatically operates the solenoid valve controlling the flow of cooling water through the field. A temperature safety limit switch is also in contact with the field which protects the shaker from overheating from lack of cooling water or other causes. If this switch trips, the system is automatically shut down and requires manual restarting.

An accelerometer may be attached to the internal end of the table central flanged load attaching insert. This accelerometer, in conjunction with the Dial-A-Gain instrument and the automatic shaker control vibration meter, indicates shaker table vibratory displacement, velocity or acceleration. Normally this accelerometer is shipped separately to allow mounting directly on the specimen or fixture, which is the preferred method of control.

11. Electronic Power Amplifier.

The Electronic Power Amplifier input is connected to the controlling oscillator signal source and the output is connected to the driver coil of the Shaker. The oscillator generates a low power, low voltage signal which is amplified by the Electronic Power Amplifier to the necessary power and voltage levels to cause the a-c currents to flow through the driver coil as required to generate rated force. The Power Amplifier is of straight forward design to provide the necessary power levels through the operating frequency range without introduction of significant distortion. The Amplifier is described in detail in the following pages.

## III. Control Console

The Control Console contains the Servo Programmer, the oscillator, the Power Supply for the shaker field, the signal conditioning amplifier for the accelerometer, the control circuitry, pilot lights, driver coil and field coil ammeters, interlocks and the system power switches. All operating controls are located in the panel above the writing surface of the Console.

### A. The Oscillator

The Oscillator originates the signal voltage which is fed to the Servo-Programmer and Power Amplifier, which, in turn causes an alternating current to flow through the driver coil of the shaker. The driver coil current causes the shaker table motion. Hence the frequency of shaker table motion is controlled by the frequency generated by the oscillator.

The Oscillator may be used manually by the independent adjustment of the frequency dial to any frequency from 5 to 5000 Hz. The oscillator also may be used with automatic sweeping between settable high and low frequency limits and with an adjustable sweeping rate.

### B. Servo Programmer

Constant set values of shaker table displacement, velocity and acceleration can be maintained during frequency sweeping by using the electronic servo control. In addition to holding displacement, velocity or acceleration constant the control can be set to automatically transfer from constant displacement control to constant acceleration control with increasing sweep frequency with the transfer occurring at a manually settable frequency. Also the control can be set to automatically transfer from constant velocity to constant acceleration, or constant displacement to constant velocity. The Servo-Programmer adjusts the magnitude of the oscillator output voltage fed to the power amplifier to account for variations in system frequency response due to resonant characteristics of the items mounted on the shaker table and the inherent shaker system response itself.

If desired, the frequency may be varied manually or held at a fixed frequency while the Servo-Programmer maintains the set value of displacement, velocity or acceleration, or an automatic transfer at a set frequency from displacement to acceleration control, velocity to acceleration, or displacement to velocity.

C. The Vibration Meter

The Servo-Programmer panel includes an indicating meter which indicates displacement, velocity or acceleration of the shaker table motion in conjunction with the accelerometer at the shaker table, and signal conditioning amplifier.

Each channel is provided with a selector switch which is used to select displacement, velocity or acceleration and range switches provide convenient scale readings for a wide range of amplitudes of each function.

D. Signal Conditioning Amplifier

This is a multipurpose instrument which allows monitoring acceleration from any piezoelectric accelerometer.

In order to make the built-in vibration meter in the Servo-Programmer read correctly with any accelerometer, all that is necessary is to adjust the sensitivity dial on the panel to correspond to the sensitivity of the accelerometer being used.

## 7. SCHEMATICS - LAYOUTS

S.N. 383

| Fig. | Title | | Dwg. No. | Rev. |
|---|---|---|---|---|
| 7.35 | Circuit - Meter Control | -D-SERVO | C13741 | D |
| 7.36 | Layout - " " | -D-SERVO | B13718 | C |
| 7.37 | Circuit - Mode Control | -E-SERVO | C13740 | A |
| 7.38 | Layout - " " | -E-SERVO | B13716 | B |
| 7.39 | Circuit - Switching Ampl. | -SW-SERVO | C13742 | D |
| 7.40 | Layout - " " | -SW1-SERVO | C13734 | NC |
| 7.41 | Layout - " " | SW2,SW3-SERVO | C13732 | NC |
| 7.42 | Layout - " " | SW4-SERVO | C13733 | NC |
| 7.43 | Layout - Servo Power Supply | PS-SERVO | B13724 | NC |
| 7.44 | Layout - Osc. Power Supply | PS-OSC-1 | B13821 | A |
| 7.45 | Layout - Osc. Power Supply | PS-OSC-2 | B13822 | NC |

| CARDS | PIN | VOLTAGES (VDC) | MAX RIPPLE |
|---|---|---|---|
| ALL OSC CARDS | 1 TO 11 | +15.0 V ± 0.5 V | 50 mV pp |
| ALL OSC CARDS | 22 to 11 | -15.0 V ± 0.5 V | 10 mv pp |
| ALL OSC CARDS | 5 to 11 | + 5.0 V ± 0.2 V | 50 mV pp |
| E-OSC, F-OSC | 3 to 11 | +10.06V ± .01 V | 10 mV pp |
| ALL SERVO CARDS | 1 to 11 | +15.5 V ± .2 V | 10 mV pp |
| ALL SERVO CARDS | 2 to 11 | -15.5 V ± .2 V | 10 mV pp |
| ALL SERVO CARDS | 22 to 12 | + 5.0 V ± 0.2 V | 50 mV pp |

TABLE 6.4 Power Supply Voltages

## 6.5 Component Replacement

Component replacement on a printed circuit card should be a rare occurrence, but the following instructions should be followed to prevent damage to the printed circuit.

Most integrated circuits are socket-mounted, and may be replaced easily. Should a CMOS switch (AD7513) require replacement, it is important that the handler be physically grounded to prevent static charges from damaging the unit.

Should a permanently mounted part require remplacement, remove the excess solder at the points of insertion with a soldering iron and a desoldering wick (Dri-wick-American Electrical Heater Co.). On a single-sided board, the component can usually be lifted out with long-nose pliers. On a double-sided board with plated-true holes, however, it is necessary to heat each insertion point while pulling on the lead with pliers. Take care not to delaminate the printed circuit conductors.

There are also specifically-shaped tools available with soldering irons for removing multi-pin devices from two-sided boards.

## 6.6 Component List

Listed below is ordering information for integrated circuits, semiconductors, and other critical components used in the Model OSP-4. Other resistors and capacitors are widely available from many sources.

The amplifier (Z1, Z2, Z3) accepting the oscillator output signal predistorts the AC input to the AGC amplifier so that the output from the differential amplifier Z7 has extremely low distortion.

CMOS switches Z9 and Z11 route the AGC output to the power amplifier or back to the control input (CAL mode), depending on the state of the MODE CONTROL.

5.15 The METER AMPLIFIER card (D-SERVO) contains a precision full-wave rectifier, and a three-pole low-pass filter for providing a combination of low ripple and minimum rise time for the DC signal driving the VIBRATION METER.

5.16 The MODE CONTROL card (E-SERVO) contains a logic network and four R-S flip-flops to provide pushbutton control of the four servo modes, and the logic signals necessary to control the CMOS switches on other cards and the mode indicator lamps.

5.7 The COUNTER CONTROL card (G-OSC) provides timing control circuitry for the DISPLAY COUNTER. The power frequency signal is divided to provide three pulses every 0.1 sec. The first pulse strobes the content of the counter into the display buffer, the second pulse resets the counter and the third pulse interrupts the input to the counter during the first two pulse periods.

5.8 The DISPLAY COUNTER card (L-OSC) is a four-decade counter and four-digit display. As explained in 5.7, the frequency measurement is updated every 0.1 second.

5.9 The SINE GENERATOR card (I-OSC) contains an eight-bit reversible shift register (Z1, Z3), eight current switches (Z2, Z4), and a signal inverter (Z5, Z6).

The shift register shifts at the 32f rate and reversing is provided by the 2f signal. Zeroes are shifted in from the low side (1) and ones from the high side of the shift register (8). Each current switch feeds a current into the junction of an op amp for a zero input from the shift register. Thus as zeroes are shifted into the shift register, the currents from each current switch are successively added, and produce one quarter of a stepped sine wave at the op amp output. The 2f signal causes the zeroes to be shifted out and the second quarter of the sine wave is produced.

The 1f square wave causes signal inversion over the next half cycle, thus producing the final half of the complete stepped sine wave appearing at 19 and 20.

The harmonic distortion is approximately 4% with mostly 31st and 33rd harmonics.

5.10 The TRACKING LO-PASS card (N-OSC) filters these high order harmonics. Two separate two-pole sections are cascaded. The variable cutoff frequency is produced by using matched electrically variable resistors (EVR) in conventional low-pass active filter circuits. The EVR resistance is controlled to be inversely proportional to frequency.

Servo-programmer circuit description is found in Sections 5.11 through 5.16.

5.11 The CHARGE CONVERTER card (A-SERVO) contains the charge converter circuit (Z1, Z2), the DIAL-A-GAIN sensitivity normalizer (Z3), a three-pole Butterworth low-pass filter (Z3), the velocity integrator (Z4, Z5) and the displacement integrator (Z6, Z7). The acceleration signal (pin 10) is used for control when an external signal conditioner is not used. The acceleration signal (13) and displacement signal (19) are bussed to the SWITCHING AMPLIFIER cards for control selection and monitoring purposes.

Then for equal frequencies of the OSP-4 and the external oscillator at 5, 15, 50, 150, and 500 Hz check that the output voltages do not vary from a median value (1.00 V ±3%) by more than ±1%. If the above tolerances cannot be met, the EVRS (V1, V2, and V3) are probably not matched well enough. Consult factory. Replace A-SERVO card.

## 4.21 AGC Amplifier (C-SERVO)

4.21.1 3RD, 2ND - These adjustments control the third harmonic and second harmonic distortion components from the AGC amplifier. They also affect the maximum output and balance, respectively, so they must be adjusted first. A distortion analyzer (HP331A or equivalent) must be used for the adjustment. Turn ADJ MAX OUT on rear panel max CW and back off 1/2 turn. With the same connections and settings in 4.20.1, except that the MULTIPLIER on the active segment is X100, and the COMP. OUT. is monitored by the distortion analyzer, adjust 3RD and 2ND for minimum harmonic distortion (less than 0.2% typically).

4.21.2 GAIN - Put SERVO in OFF mode and turn MAX OUT max. CW. Adjust GAIN for 10 V rms at COMP. OUT jack.

4.21.3 80 dB. Put SERVO in STBY mode and MAX OUT max CW. Monitor voltage at COMP OUT with CRO. Adjust 80 dB until signal component voltage <u>just</u> disappears and only wideband noise remains.

4.21.4 BALANCE - Provide the following connections and settings:

| | |
|---|---|
| Connect | COMP OUT to 10 mV/g IN |
| Set INPUT | SELECTOR to 10 mV/g IN |
| Monitor | COMP OUT with ACVM and CRO |
| Set | MULTIPLIER to X100 - Segment 1 |
| | MULTIPLIER to X10 - Segment 2 |
| | LEVEL VERNIERS to 1.000 (Segs. 1 & 2) |
| | FREQUENCY to 5 kHz |
| | SERVO MODE to ON |
| | MAX SPEED to 1 K dB/sec |
| | MAX OUT to 10 V (max CW) |

As in Section 4.11 rotate CROSSOVER 1-2 back and forth so that switching from Segment 1 to Segment 2 and back again occurs. View the envelope of COMP OUT with the CRO using a relatively slow sweep. A displacement of the smaller envelope from the center of the trace just following switching requires adjustment of the BAL control. See Fig. 4.3

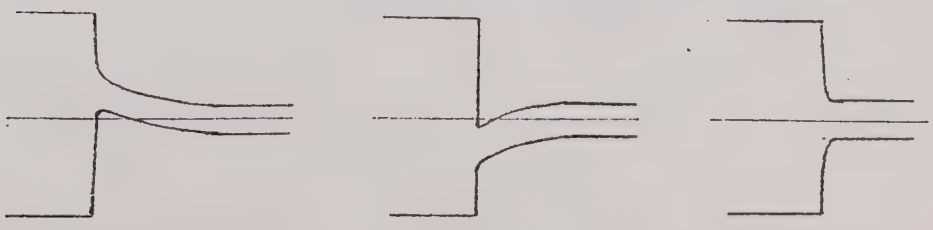



Fig. 4.3 Adjustment of BAL Control

4.18.4 High Frequency Distortion. Second-harmonic distortion at high frequencies (above 1 kHz) indicates delay unbalance in the signal inverter. Capacitor ** (Fig. 7.20) is adjusted at the factory to minimize distortion.

4.18.5 GAIN (RA) - If voltage at OSC OUT is not 1 V rms ±5% at 1000 Hz, adjust RA.

## 4.19 Switching Amplifiers (SW 1 through SW 4 - SERVO)

4.19.1 METER CAL - The factory adjustment follows:

Apply .050 V rms, 100 Hz to 10 mV/g IN.
Monitor SW (1, 2, 3, 4) - SERVO-13 (meter Bus).
Set ACC/DISP to ACC; MULTIPLIER(S) to X10.

Adjust METER CAL for each segment so that monitored voltage is exactly .050 V rms. This assures that the meter indication will be the same for each segment on the 10 g (.1 in.) range.

4.19.2 BALANCE - For a setting of 1.0 turns on each LEVEL VERNIER and with MULTIPLIERS to 100X, monitor the DC voltage at TP1 for SW1. Adjust BAL for 0 ±20 mV DC at TP1. Repeat for SW2, SW3 and SW4.

4.19.3 SET HI - This adjustment provides the proper gain for the 10-turn setting of the level vernier. For the input voltage and settings in 4.19.1, monitor Pin 14 (Signal Bus), and set all LEVEL VERNIERS at 10.00 turns. Adjust SET HI for all segments so that the measured voltage at Pin 14 is exactly 0.40 V rms.

4.19.4 SET LO - This adjustment provides the proper gain for the one-turn setting of the LEVEL VERNIER. Following 4.19.3, reduce the input voltage to 5.00 mV rms and set all LEVEL VERNIERS at 1.00 turns. Adjust SET LO for all segments so that the measured voltage at Pin 14 is exactly 0.40 V rms.

## 4.20 AGC Control (B-SERVO)

The adjustment of the tracking high-pass filter section is necessary only if the tolerances for the readings in Table 4.3 cannot be maintained over the frequency range for the displacement calibration in 4.9. The adjustment of the tracking resistance circuit that controls compressor speed is necessary only if gross errors are noticed in compression speed (Section 4.11).

## 4.15 Sweep Circuit (Cards C-OSC, D-OSC)

4.15.1 Sweep HOLD - If drift of oscillator frequency in the HOLD mode is greater than 2.5 Hz/min or 2.5%/min below 100 Hz, adjust HOLD pot. on D-OSC card for minimum drift at a frequency of 1000 Hz.

4.15.2 INT. ZERO, EXT. ZERO, BAL (C-OSC) - These controls affect the accuracy of long sweep times (Section 4.4) and should not be changed unless the sweep times of 10 min and above are inaccurate.

With LOWER LIMIT and UPPER LIMIT CCW, short pins C-OSC-8 and 9 to reference 11. With SWEEP TIME set at 10.0 min. adjust INT. ZERO to produce 0 V DC ±1 mV at C-OSC-6. Then adjust EXT. ZERO to produce 0 V DC ±1 mV at C-OSC-TP1. Finally adjust BAL to produce 0V DC ±1 mV at C-OSC-TP2.

4.15.3 RATE (C-OSC) - Set SWEEP TIME at 1.0 min. for 5 Hz to 5 kHz sweep. Use RATE (RT) adjustment to get upward sweep time at 1.0 min ±1 sec. Downward sweep should be within this accuracy also. If not, the nominal 220k resistor marked ** near Z2 must be changed.

4.15.4 Set SWEEP TIME at 10.0 minutes or longer if desired for 5 Hz - 5 kHz sweep. If upward sweep time is not within 2% tolerance, turning EXT. ZERO pot one turn CW increases the upward and downward sweep time approximately 10 sec. Following this, the downward sweep time may be adjusted by adjusting the BAL pot. Turning the BAL pot one turn CW increases the downward sweep time 10 sec.

## 4.16 High Frequency Generator (Card F-OSC)

4.16.1 BAL and ZERO - Monitor voltage at LIN FREQ with digital DCVM. With oscillator in MAN, adjust voltage to 10.0 mV DC. Monitor waveform on F-OSC-9, and measure freq/period at OSC. OUT. Monitored waveform should be symmetrically triangular and measured frequency should be 5.0 Hz (.2000 sec period). Turn both BAL and ZERO CW (CCW) increase (decrease) frequency if necessary, taking care to preserve symmetrical triangular waveform at F-9.

4.16.2 RANGE (RG) - Adjust voltage on F-OSC-2 to 10.00 V DC. Front panel indicator should show 5000 ±100 Hz. Adjust RANGE potentiometer to change frequency reading if necessary. Repeat 4.16.1.

4.16.3 If adjustments are necessary in 4.16.1 and 4.16.2, return to Section 4.6 and check LOG FREQ. output.

## 4.11 Compression Speed

4.11.1 Provide connections and monitor as in 4.7.1.

4.11.2 Provide settings as in 4.8.2 except set:

LEVEL VERNIER (Seg 1) to .800 (8 turns)
LEVEL VERNIER (Seg 2) to .600 (6 turns)

4.11.3 At a frequency of 5 Hz, adjust CROSSOVER 1-2 so that rotating it back and forth slightly causes switching from Segment 1 to Segment 2. View the envelope of the COMP OUT signal with the CRO, using a slow sweep (.5 sec/cm). When the switching of control takes place, the trace on the CRO should appear as in Fig.4.2.

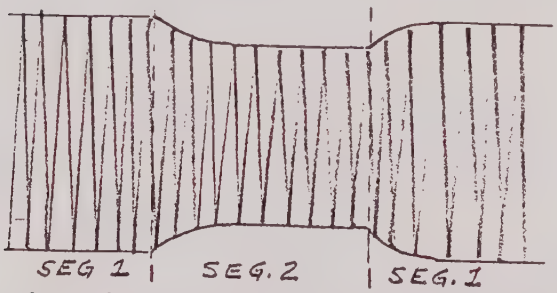



FIG. 4.2
ENVELOPE OF
CONTROL SIGNAL

4.11.4 The time constant for the signal envelope for the oscilloscope trace viewed in 4.11.3 should be 1.0 +0.5 sec. This corresponds to a compression speed of 10 dB/sec. The time constant is the time the envelope takes to make approximately 2/3 the change between the initial and final values.

4.11.5 Change the frequency to 5 kHz, and adjust CROSSOVER 1-2 to provide switching as in 4.11.3. Use a faster sweep on the CRO ( 2 msec/cm). The measured time constant for the envelope when switching takes place should be 3.0 ±1.5 msec. This corresponds to a compression speed of 3000 dB/sec.

4.11.6 Should the measurement in 4.11.4 and 4.11.5 be out of tolerance, consult Section 4.20.4.

## 4.12 COMPRESSION Meter

4.12.1 With connections as in 4.7.1 and settings as in 4.8.2, except that LEVEL VERNIER for Segment 1 is adjusted to .141 (1.41 turns) to give 1.41 g peak (10 mV rms), COMPRESSION meter should read 60 dB.

4.12.2 Rotate MAX OUT CCW to RESET, and COMP meter should read 0 dB.

4.12.3 If meter requires readjustment, for condition in 4.12.2, adj. HI pot. on the small card bolted to the meter ter-

4.6.3 If above readings do not fall within tolerances, set 1.200 V at LOG DC output with UPPER LIMIT in RESET UP. Adjust LOG BAL on E-OSC card to give 5000 Hz on frequency indicator.

4.6.4 Then set 0.600 V DC on LOG DC output with MAN and FINE and COARSE controls. Adjust LOG RANGE for exactly 157 Hz.

4.6.5 Finally set 0.00 V DC on LOG DC output in RESET DN with LOWER LIMIT pot. Adjust LOG ZERO on E-OSC card for 5.0 Hz.

4.6.6 Repeat adjustments on E-OSC card in 4.6.3, 4.6.4, and 4.6.5 if necessary.

## 4.7 Maximum Output - AGC Amplifier

4.7.1 Monitor: COMP OUT with ACVM and CRO

4.7.2 Set: OSC MODE to MAN
SERVO MODE to OFF
MAX OUT to RESET, then to full CW

4.7.3 Adjust oscillator frequency to 1 kHz. COMP OUT should be 9.5 V rms with no visible clipping or distortion. Vary the frequency over the three-decade range. No more than 20% frequency response error should be evident with no visible distortion.

4.7.4 Change setting of ADJ MAX OUT if voltage is not within tolerances, or change setting of GAIN pot. on C-SERVO board (AGC Amplifier).

## 4.8 Acceleration Calibration - Vibration Meter

4.8.1 Provide connections and monitor as in 4.7.1. Make sure that vibration meter is at zero with no power on. Mechanical zero adjustment is on rear of meter.

4.8.2 Set:

| | | |
|---|---|---|
| COMP OUT | to | 10 mV/g IN |
| MAX OUT | to | Full CW |
| MAX SPEED | to | 3k dB/sec |
| CROSSOVERS | for | active Segment 1 |
| A-D SELECTORS | to | ACC |
| F.S. RANGES | to | 10 (X10 MULT) |
| LEVEL VERNIER | to | 1.000 (10 turns) |
| SERVO MODE | to | ON |

4.8.3 The ACVM should read 100 mV pk (70.7 mV rms) ±1% and the VIBRATION METER should read 10.0 ±1%. If either reading is out of tolerance, adjust SET HI on SW1-SERVO for exactly 10.0 on the VIB. METER, and then adjust METER CAL for exactly 70.7 mV rms on the ACVM.

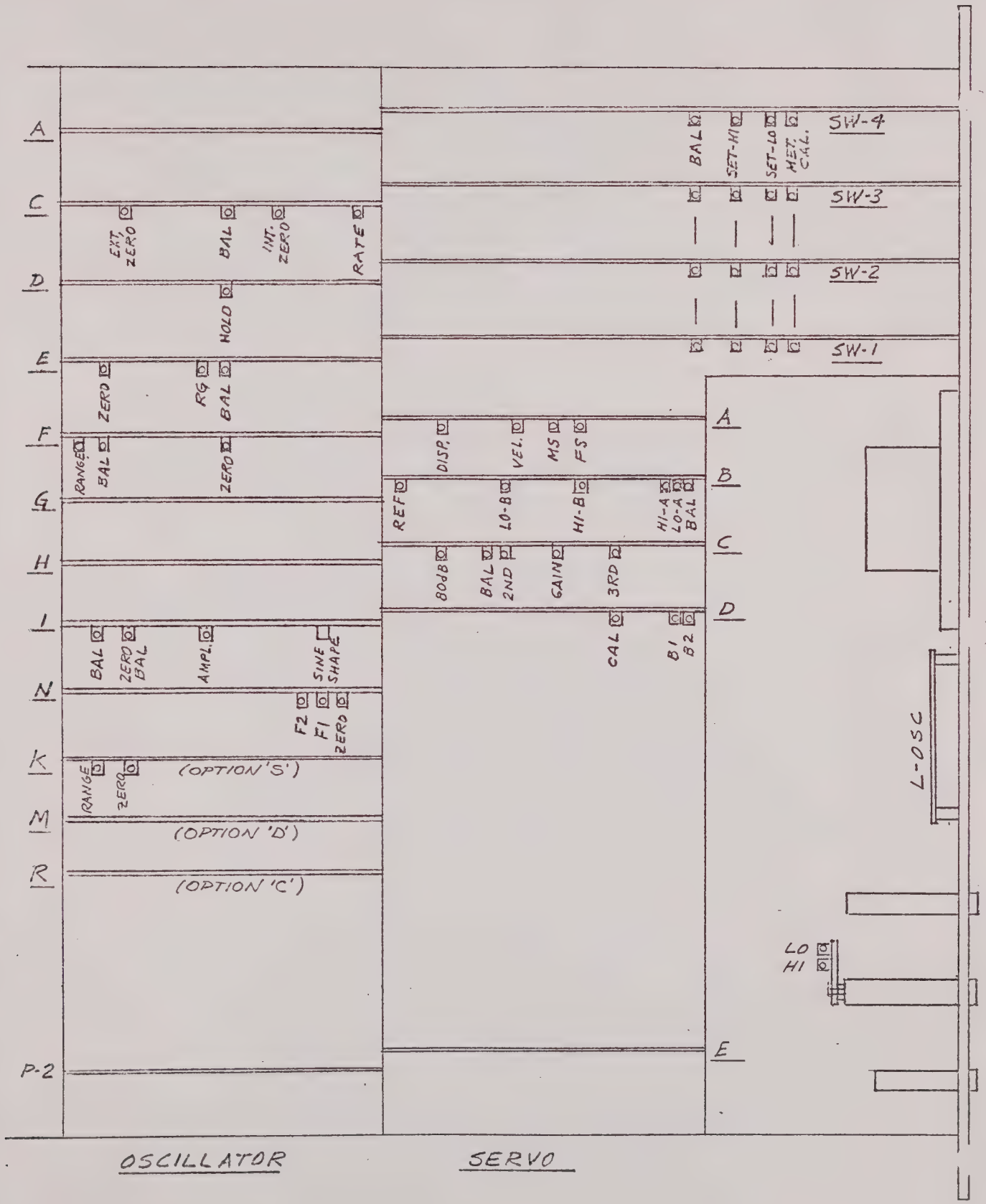



FIG. 4-1

MODEL OSP-4 CARD & ADJUSTMENT LOCATIONS

3.3.5 Following the required number of test sweeps, or for any other reason, the test may be terminated by pushing the STBY button. The vibration level decreases to zero, and the oscillator goes automatically to the HOLD mode.

3.3.6 Should any attempt be made to push an A-D selector, MULTIPLIER, RESET, MAN, LEVEL CAL, or OFF button, the servo automatically goes to STBY. Other instrument switches in the external interlock string have the same effect. To reestablish servo control, examine all switch settings carefully, and repeat Section 3.3.2.

## 3.4 MANUALLY CONTROLLED TEST

3.4.1 Establish the following settings:
MAX OUT to RESET
COMP MODE to OFF
Turn all CROSSOVER controls CW until stop is reached.
A-D, MULTIPLIERS - as desired for function and F.S. RANGE for Segment 1
OSC MODE to MAN

3.4.2 Adjust the oscillator frequency with the COARSE and FINE controls as needed, and turn MAX OUT CW until desired vibration level is indicated on the VIBRATION METER.

3.4.3 Use the MAX OUT control to adjust the vibration level as frequency is varied.

3.4.4 The MULTIPLIERS and A-D selectors may be switched without interrupting the test because the VIBRATION METER merely monitors the vibration level. However, any attempt to change the SERVO MODE will cause the servo to go to STBY initially. However, holding the ON or LEVEL CAL buttons in will allow the servo to cycle to these modes after a delay of a second or two. Changing the OSC MODE to RESET UP or DOWN from MAN also causes the servo to go to STBY.

## 3.5 OPERATION WITH MODEL MAC-8 SIGNAL AVERAGER

3.5.1 Refer to Section 3.1.4 for connections.

3.5.2 The program setup follows the same procedure as in Section 3.2, except that the internal charge amplifier is not used. The MAX SPEED may have to be set lower than 1K to keep distortion components below acceptable limits due to the unusual nature of the control signal (See MAC-8 manual). Amplitude servo control of the average acceleration may be obtained only for acceleratior segments of the program, since integration of the multiplexed control waveform is meaningless and produces spurious results.

3.1.5 With Model ACS-6 Acceleration Control Selector
Connect: J1-1 (OSP-4) to J3-6 (ACS-6)
J1-13(OSP-4) to J3-1 (ACS-6)
J1-2 (OSP-4) to J3-2 (ACS-6)
J2-1 (OSP-4) to J3-5 (ACS-6)
J2-2 (OSP-4) to J3-3 (ACS-6)
J2-1 (ACS-6) to J2-2 (ACS-6)

(Above may be in a single cable assembly.)

SERVO (10 mV/g Signal Conditioners) to ACCEL IN 1 thru 6 (ACS-6)
LOG FREQ (OSP-4) to LOG FREQ IN (ACS-6)
OUTPUT (ACS-6) to 10 mV/g IN (OSP-4)

3.1.6 Interlocks
Make sure that the interlock cable supplied with the system is firmly connected to each system instrument. If operation of the OSP-4 is desired without a cable connection to rear panel connector J2, a jumper between pins 1 and 2 is necessary to get the OSP-4 out of the STBY mode. The normally closed interlock circuits of other instruments are put in series with pins 1 and 2. Pins 3 and 4 are used to provide an interlock with the power amplifier so that the power amplifier cannot be turned on initially if the MAX OUT is not in the RESET position.

## 3.2 PROGRAM SETUP

3.2.1 Turn system on or otherwise apply AC power to the line connection of the OSP-4. The STBY light should go on. Turn all CROSSOVER controls Max CW until stop is reached, turn MAX OUT CCW to RESET, and set MAX SPEED to 1K.

3.2.2 If the internal charge amplifier is used,set the accelerometer sensitivity in pC/g by means of the rear panel SENS RANGE switch and ten-turn SENS DIAL. Lock the SENS DIAL.

3.2.3 For the desired test program, switch the A-D SELECTORS for each segment as required, provide the proper F.S. RANGE for each segment by selecting the correct MULTIPLIERS, and set the significant digits for the test levels on the ten-turn LEVEL VERNIERS. Lock the dials and check all settings.

If less than four segments are required, use the lowest numbered segments.

3.2.4 Switch the OSC MODE to MANUAL (This overrides the HOLD control), and rotate the COARSE and FINE tuning controls to set the crossover frequency between program segments 1 and 2. The indicator for segment 1 should be on. Rotate the CROSSOVER 1-2 control CCW until switching from segment 1 to segment 2 is indicated. Rotate the control back and forth until a very slight rotation causes switching. This establishes an accurate setting of the control.

2.29 SYNC (Optional) - Provides a ramp output of approximately 10 V p-p at 1/3 the oscillator frequency. When applied to the X axis of an oscilloscope exactly 3 cycles of the fundamental frequency are displayed.

2.30 RECORDER (Optional) - Provides a DC voltage proportional to the log of the vibration level. Full scale range and function selection is determined by the settings for Segment 4. Output has 60 dB range for 1000 g setting. Full scale is 0 V DC and sensitivity is 50 mV/dB (1 V/decade).

2.31 FUSE - Cartridge fuse 1/2A for 115 V AC; 1/4A for 230 V AC line voltage.

2.32 LINE VOLT - A screwdriver-actuated selector switch for operation from 105-125 V AC (115V) or 210-250 V AC (230V) line voltage. Power line frequency is 50 to 60 Hz.

100 pC/g. It provides a control signal for the test, and no external signal conditioner is required.

2.17 10 mV/g INPUT - Accepts a control signal from an external signal conditioning amplifier or other accessory instrument, such as a U-D Model TF11 Tracking Filter, Model MAC-8 Signal Averager, or Model ACS-6 Acceleration Control Selector. The signal sensitivity is 10 mV/g.

2.18 CHG IN/10 mV/g Selector - A two-position, locking toggle switch which selects either of the possible control signal sources in 2.16 or 2.17.

2.19 10 mV/g OUT - Provides a normalized and conditioned 10 mV/g signal when the CHG IN is utilized. This allows external monitoring of the acceleration signal and also the use of a Model TF11 Tracking Filter without an external signal conditioner. See Section 3.1.3.

2.20 SENSITIVITY Normalization - These controls are used when the internal charge converter is used (CHG IN).

2.20.1 SENS RANGE - A two position locking toggle switch which provides two 10:1 sensitivity ranges: 1 to 10 pC/g and 10 to 100 pC/g.

2.20.2 SENS DIAL - A ten-turn precision potentiometer with a locking dial which allows settings from 0.50 to 10.50 to be dialed directly.

2.21 OSCILLATOR OUTPUT - Provides the constant 1 V rms sinusoidal output from the oscillator section over the 3 decade frequency range.

2.22 LOG FREQ - These two paralleled connectors provide a DC voltage proportional to the log of the frequency. The sensitivity is 0.4 V/decade with the output ranging from 0 to 1.2 V over the three decades.

2.23 LIN FREQ - Provides a DC voltage proportional to frequency. The sensitivity is 2 mV/Hz for the range of 5 to 5000 Hz.

2.24 COMPRESSOR OUTPUT - Provides the AGC signal to drive the power amplifier. The maximum output for 0 dB compression is determined by the MAX OUT control. With the MAX OUT full CW, a maximum output of 10 V rms is supplied.

2.25 ADJ MAX OUT - This potentiometer control is used to adjust the maximum output for system application so that maximum output from the COMP OUT jack will not damage the vibration exciter or amplifier. It is used primarily if maximum signal

| RANGE MULTIPLIERS | NOMINAL FULL SCALE RANGE | |
|---|---|---|
| | ACC (g-pk) | DISP (in p-p) |
| BOTH IN | 1000 g | 10 |
| X100 IN, X10 OUT | 100 | 1 |
| X100 OUT, X10 IN | 10 | .1 |
| BOTH OUT | 1 | .01 |

Table 2.1 Full-Scale Ranges.

The information in Table 2.1 is also summarized below the VIBRATION METER on the front panel of the OSP-4.

2.10 VIBRATION METER - The 3½ digit display indicates the vibration level associated with the active program segment. The range setting is determined by the setting of the RANGE MULTIPLIERS, and the function measured is determined by the A-D selector. Readings from 0.0 to 1.1 times the nominal full-scale range values are provided.

2.11 FREQUENCY INDICATOR - A four-digit LED display provides a direct reading of oscillator frequency from 5 to 5000 Hz to the nearest 1 Hz value. The display is updated 10 times/second.

2.12 OSCILLATOR MODE Switches and Indicators - Six pushbutton switches provide control of the oscillator. Indicator lights show the mode of operation. All buttons are momentary contact.

2.12.1 SWEEP - Depressing the momentary contact SWEEP button will initiate a logarithmic frequency sweep from any other mode. The green LED indicators show whether the oscillator frequency is going up or down. If the SWEEP mode is initiated from the MANUAL mode, the sweep will usually begin UP. If the manual frequency setting is above the UPPER LIMIT frequency, then the sweep will begin DOWN. If the SWEEP mode is actuated from the HOLD mode, the sweep direction will continue in the same direction which was in effect before the HOLD mode.

2.12.2 REVERSE - Depressing this momentary contact pushbutton changes the direction of the frequency sweep. When the oscillator is in the HOLD mode, pushing the REV button causes the sweep direction to be changed when the SWEEP button is finally pressed.

2.12.3 HOLD - Depressing the momentary contact HOLD button causes the sweep to stop at any point in the cycle. The associated yellow LED lights, and the oscillator will remain in the HOLD mode until another button is actuated. The oscillator automatically goes to HOLD from the SWEEP

2.1.4 OFF - The associated red LED indicator shows that the amplitude servo is inactive and that the compressor (AGC) amplifier is in a maximum gain state. The voltage at the COMP OUT jack is determined by the MAX OUT control. Manual or open-loop vibration testing is conducted in the OFF mode.

To initiate the OFF mode, the OFF button must be depressed after the MAX OUT control has been returned to the RESET position. The servo will go to the STBY mode if the MAX OUT control is not in the RESET position, to prevent possible specimen damage.

2.2 COMPRESSION (dB) Meter - This is a vertical edge reading meter which indicates the amount of compression or gain decrease below the maximum gain of the compressor (AGC) amplifier. In the OFF mode the reading is 0 dB; the reading in the STBY mode is greater than 80 dB; the reading for the ON and LEVEL CAL modes is between 0 and 80 dB. The compression is proportional to the gain of the shaker and amplifier and the setting of the MAX OUT control for the ON mode.

2.3 MAX OUTPUT (V) - This logarithmic-taper potentiometer fixes the maximum output voltage that can be obtained from the COMP OUT jack for 0 dB compression. Approximate voltages are noted on the front panel.

The RESET position allows the OFF mode to be established, and the MAX OUT becomes a simple gain control for this mode. For the ON and LEVEL CAL modes, an increase in the setting of the MAX OUT control causes the COMPRESSION to increase. Generally the setting of the MAX OUT control in the ON mode for vibration testing should be high enough to cause compression to be greater than 0 dB for all frequencies. The setting should usually not be disturbed during a test.

2.4 MAX SPEED (dB/sec) - This four-position switch fixes the upper limit for the compressor speed variation in the ON and LEVEL CAL modes (closed-loop operation). The speed varies continuously from 10 dB/sec at 5 Hz to the indicated upper limit (100, 300, 1K, or 3K) at 5 kHz. The variation is a straight line on log-log coordinates. For most testing the 1K position works well. Very high Q specimen resonances, or operation with a MAC-8 may require a lower setting.

2.5 Program Segment Indicators - These red LED indicators are located between the A-D selectors and the RANGE MULTIPLIERS. The lighted indicator shows the active or controlling program segment.

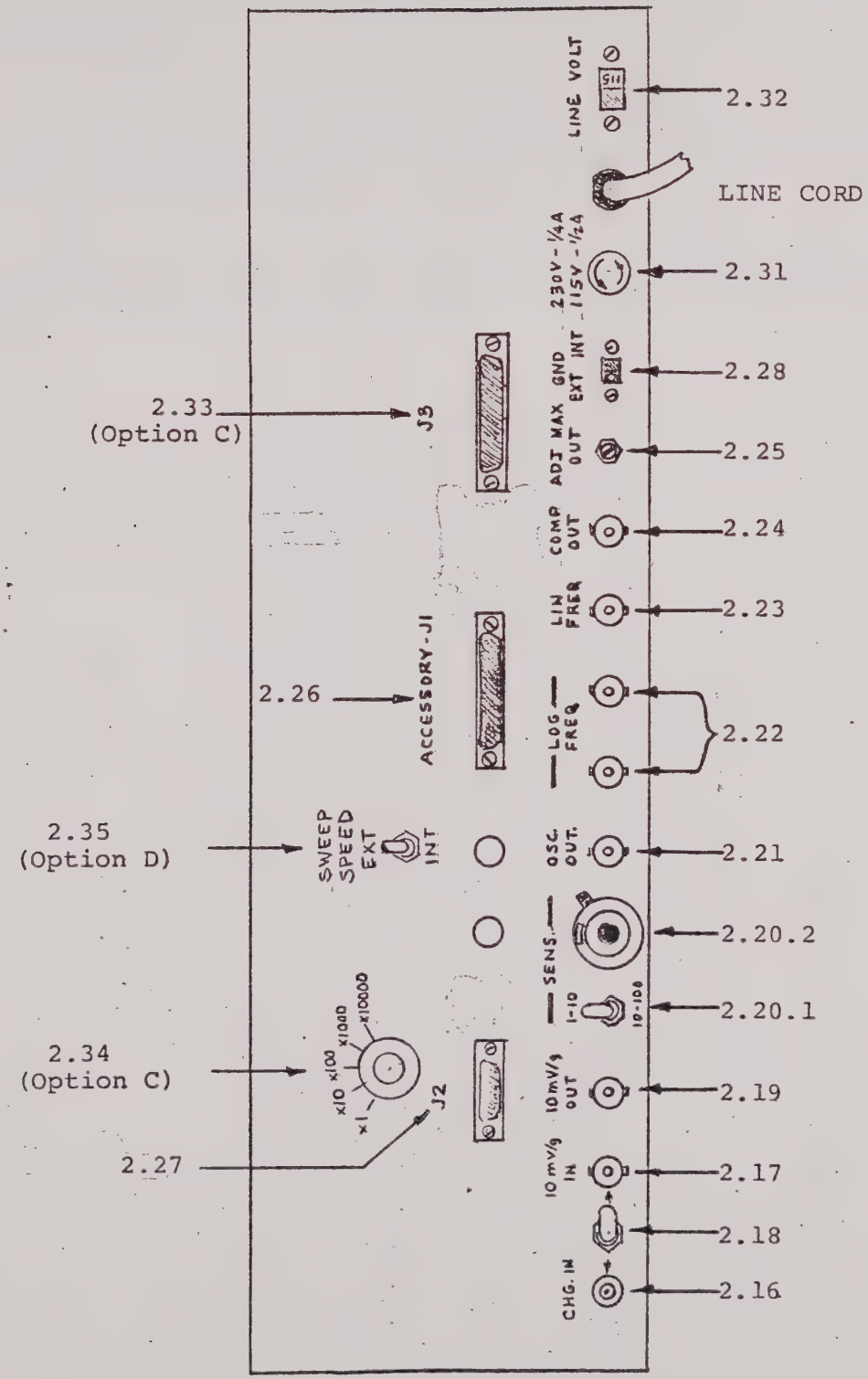



FIG. 2.2

REAR-PANEL CONTROLS AND CONNECTORS WITH SECTION REFERENCES

sequence, as the crossover frequencies are independently controlled. The ten-turn level vernier and locking dial allow the test levels to be set up without resorting to the usual "off-the-air" presetting procedure. The level verniers also do not require "touching-up" during the test.

The internal charge amplifier and sensitivity normalizer (Dial-A-Gain feature) allows almost any crystal transducer to be used directly with the OSP-4. This section may be bypassed if other instrumentation providing 10 mV/g is used.

Push-button front-panel control is utilized and the OSP-4 is fully compatible with other accessories such as the U-D Model TF11 Tracking Filter, Model MAC-8 Averaging Control, and Model ACS-6 Acceleration Control Selector.

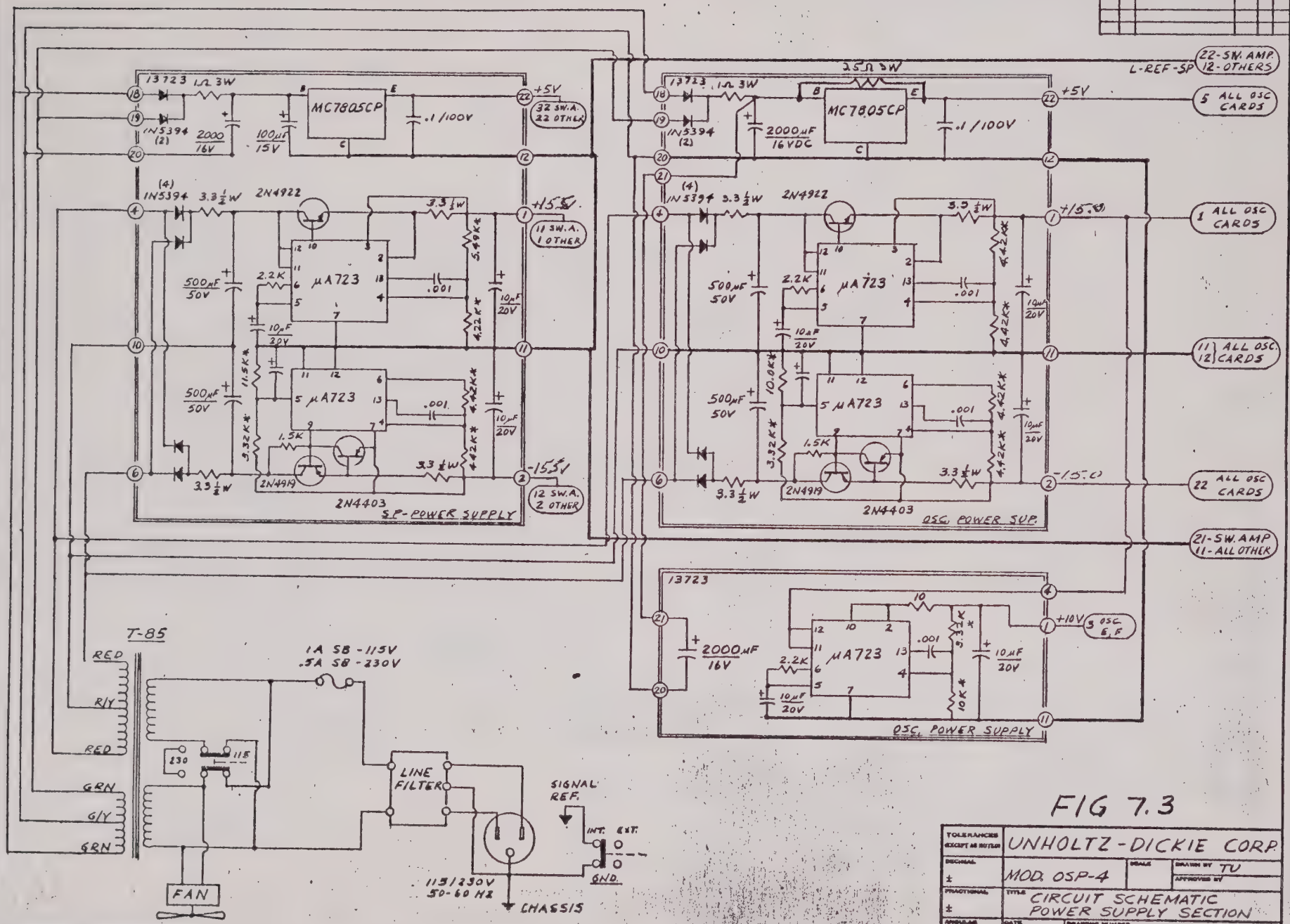
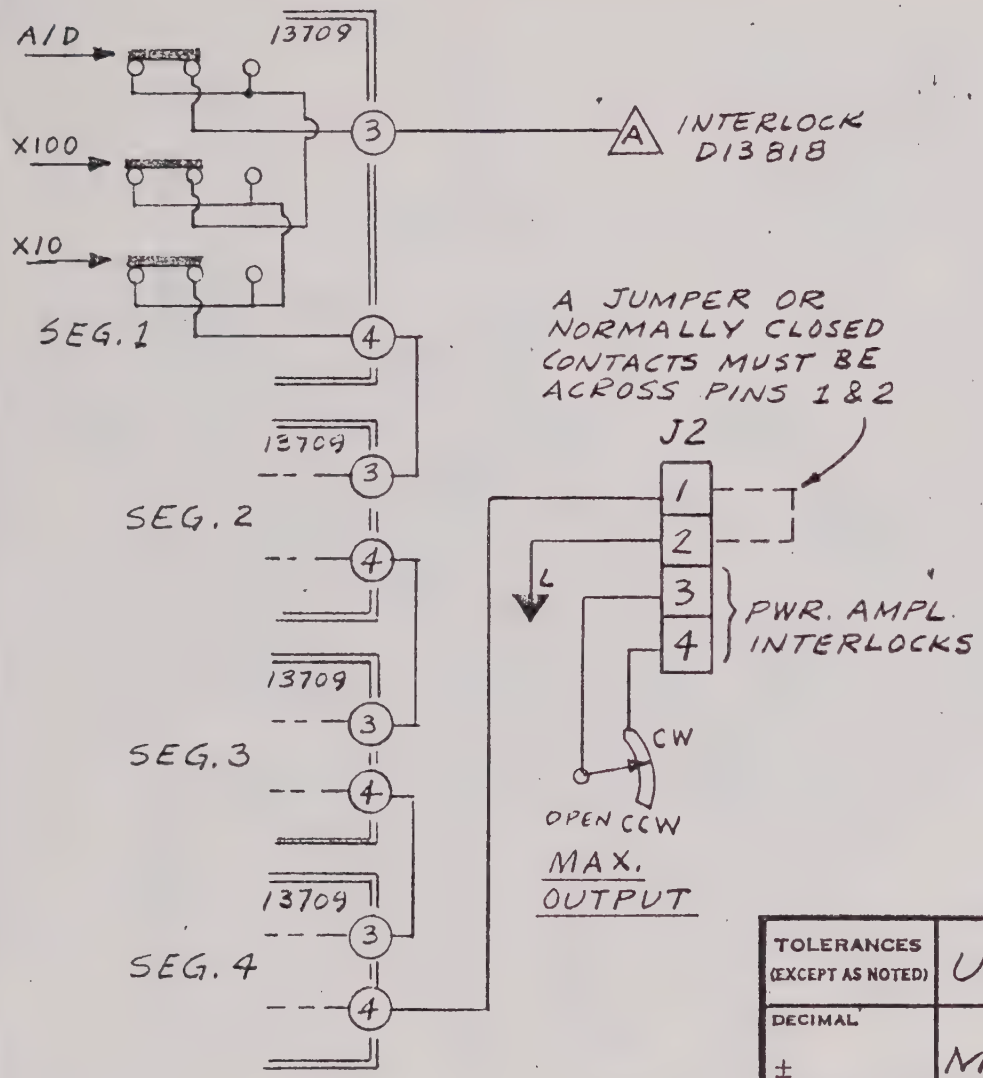



FIG 7.3

| | | |
|---|---|---|
| TOLERANCES EXCEPT AS NOTED | UNHOLTZ-DICKIE CORP. | |
| DECIMAL ± | MOD. OSP-4 | SCALE / DRAWN BY TU / APPROVED BY |
| FRACTIONAL ± | TITLE: CIRCUIT SCHEMATIC POWER SUPPLY SECTION | |
| ANGULAR ± | DATE 5-22-75 | DRAWING NUMBER C13819 |

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

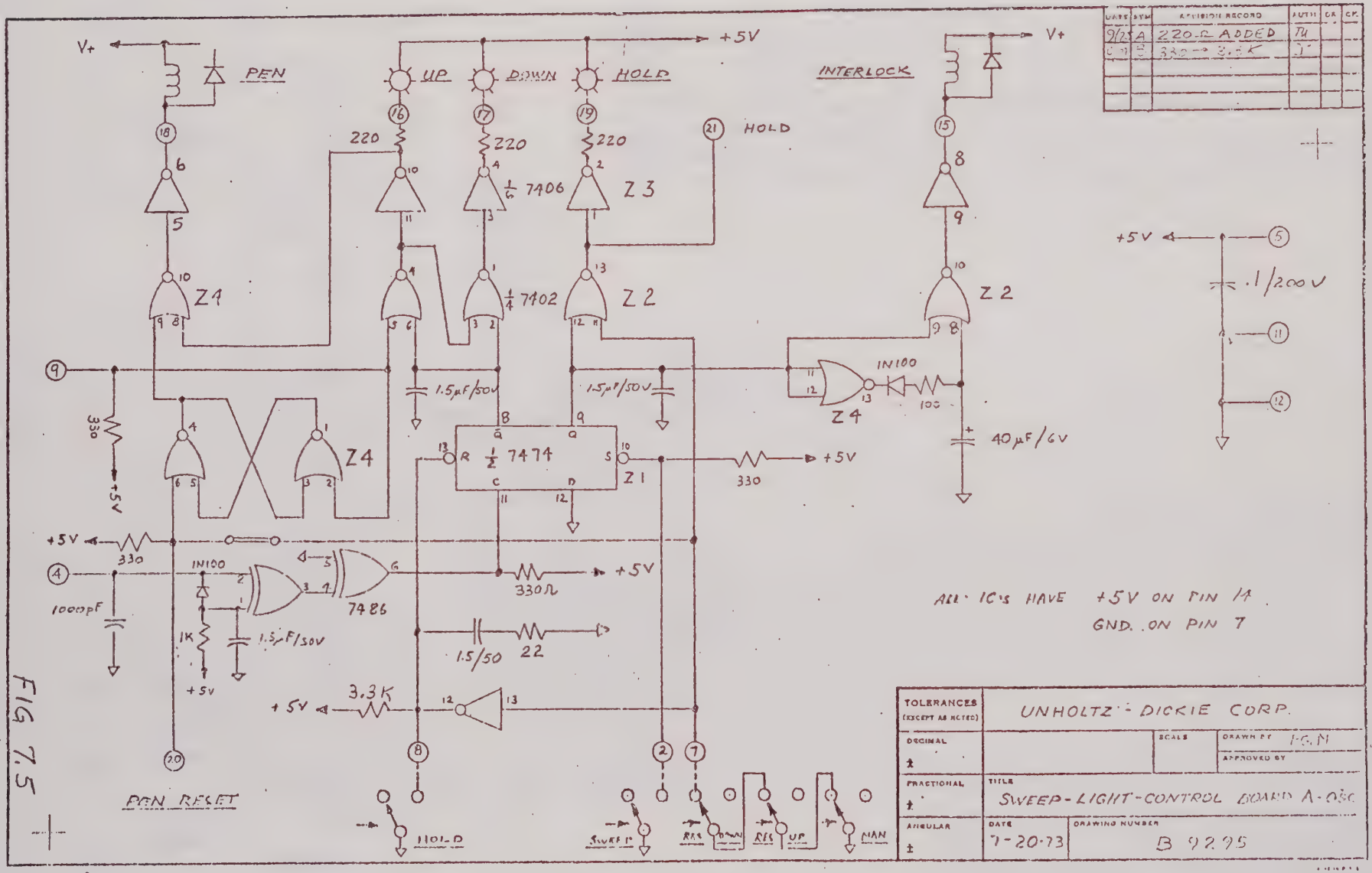



SEG. 2, 3, & 4 IDENTICAL TO SEG. 1

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | MOD. OSP-4 | SCALE — | DRAWN BY TU<br>APPROVED BY |
| FRACTIONAL ± | TITLE SIGNAL SCHEMATIC INTERLOCK CIRCUITS | | |
| ANGULAR ± | DATE 3-19-80 | DRAWING NUMBER A 13847 | |

K·E CRYSTALENE ® 10 5485 ENGINEERS' STANDARD 1984

MADE IN U.S.A.

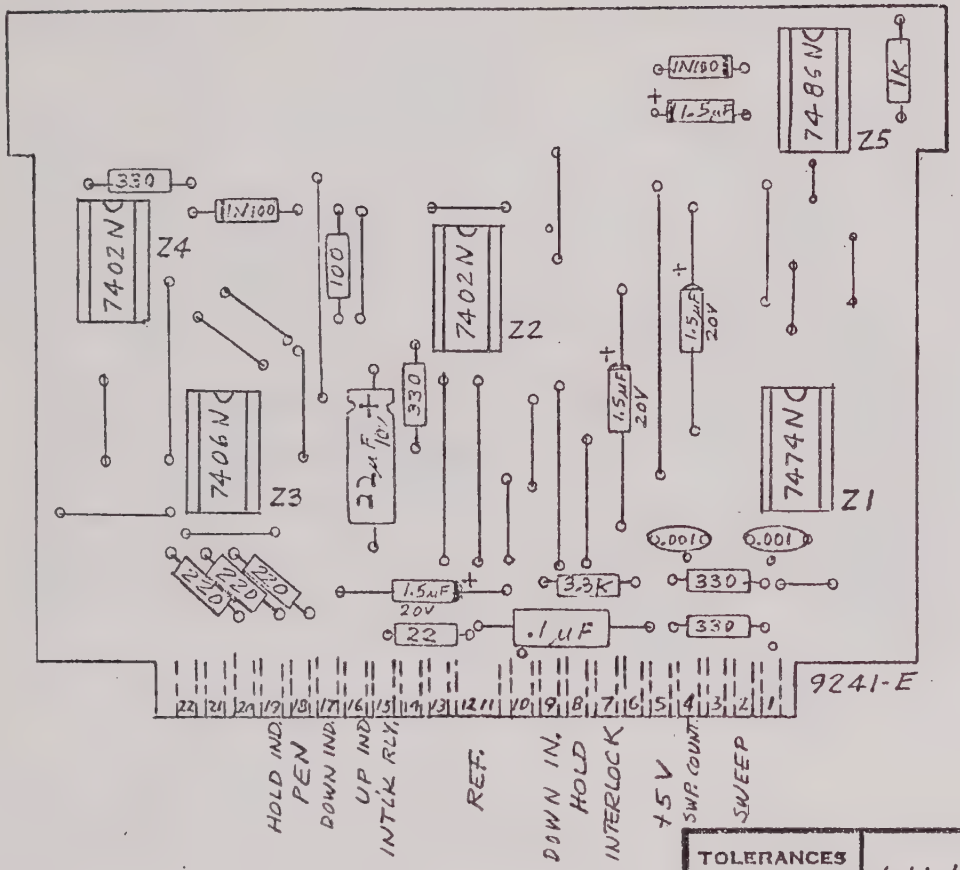



| DATE | SYM | REVISION RECORD | AUTH | CK | CK |
|---|---|---|---|---|---|
| 9/25 | A | 220-Ω ADDED | TH | | |
| 10/31 | B | 330 → 3.3K | J | | |

| | |
|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ - DICKIE CORP. |
| DECIMAL ± | SCALE |
| FRACTIONAL ± | DRAWN BY I.G.N |
| ANGULAR ± | APPROVED BY |
| | TITLE SWEEP-LIGHT-CONTROL BOARD A-080 |
| | DATE 7-20-73 |
| | DRAWING NUMBER B 9295 |

K-E

| DATE | SYM | REVISION RECORD | APP'D. | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | A | BOARD DIM. CHGD | TU | | |
| | | 220 Ω RES ADDED | TU | | |
| 11/19 | B | 330 → 3.3K | [illegible] | | |
| 5/77 | C | CARD REV. | TU | | |
| | | | | | |

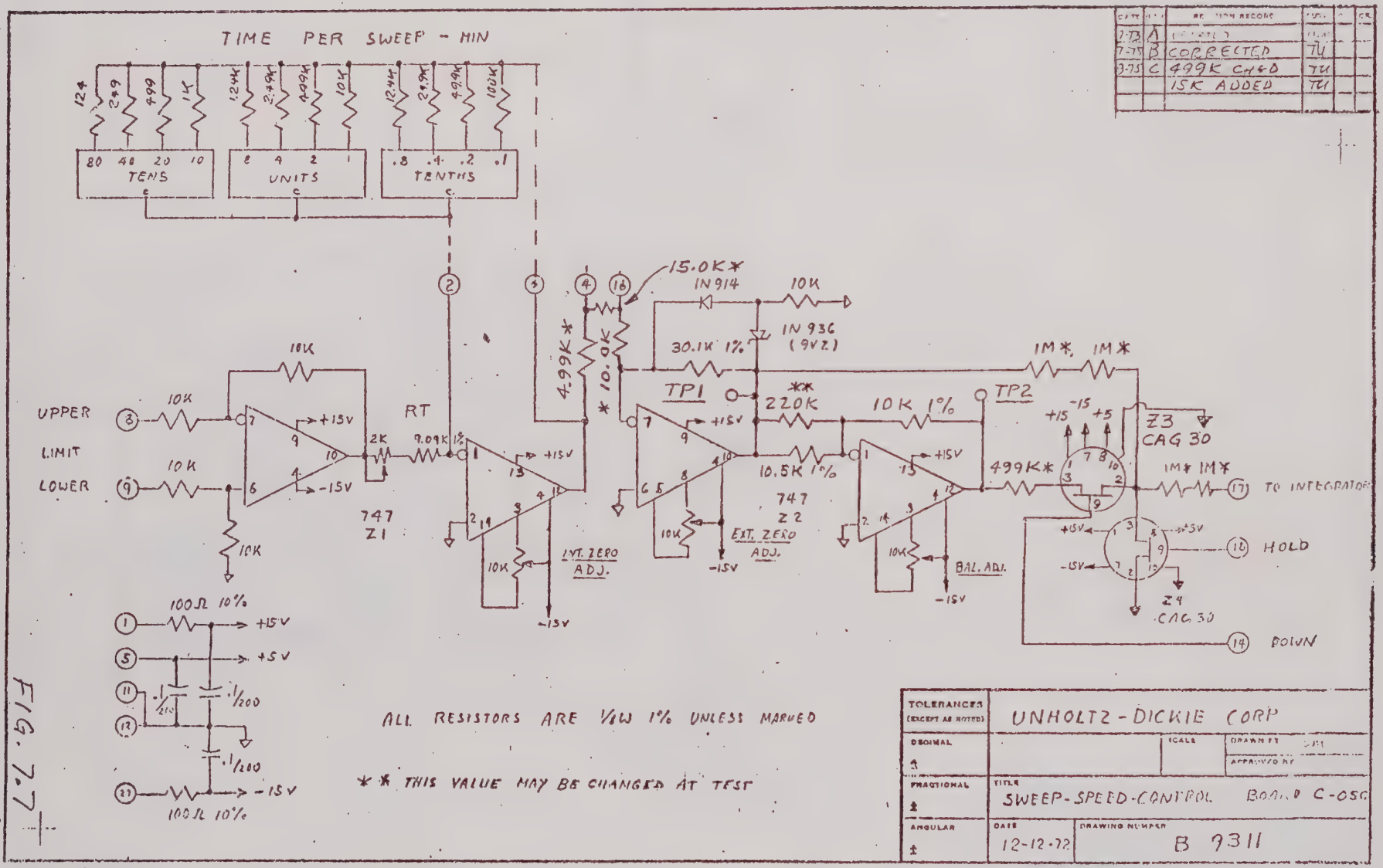



| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSP-4 | SCALE | DRAWN BY TU |
| | | | APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT A-OSC SWEEP LIGHT CONTROL | | |
| ANGULAR ± | DATE 5-15-75 | DRAWING NUMBER A9297 | |

FIG 7.6

K&E CRYSTALENE ® 10 5465 ENGINEERS' STANDARD FORM

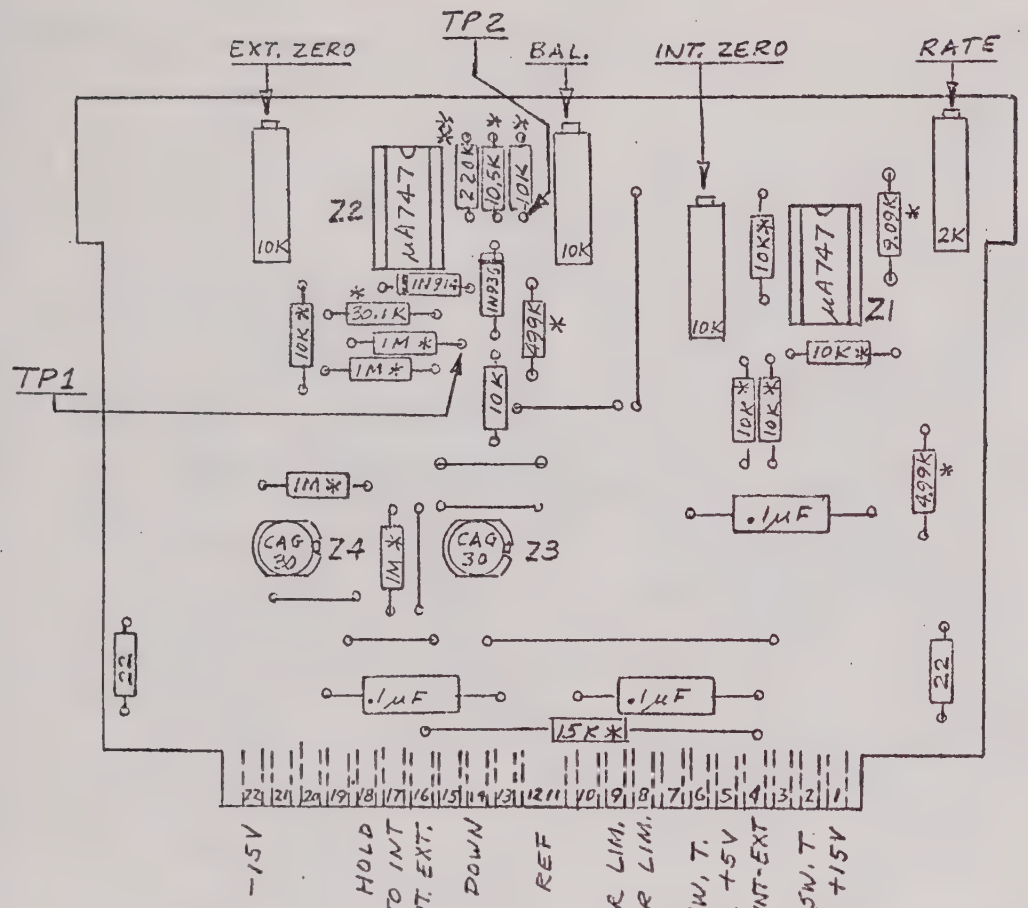
MADE IN U.S.A.




| DATE | | REVISION RECORD | | |
|---|---|---|---|---|
| 1-73 | A | (illegible) | | |
| 7-75 | B | CORRECTED | TU | |
| 9-75 | C | 499K CHGD | TU | |
| | | 15K ADDED | TU | |

FIG. 7.7

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | A | BOARD DIM. CHGD | TU | | |
| | | 15K 1% (16 TO 4) | TU | | |
| 9-75 | B | 499K* POS. CHGD | TU | | |
| | | | | | |
| | | | | | |




** ADJUSTED AT FACTORY

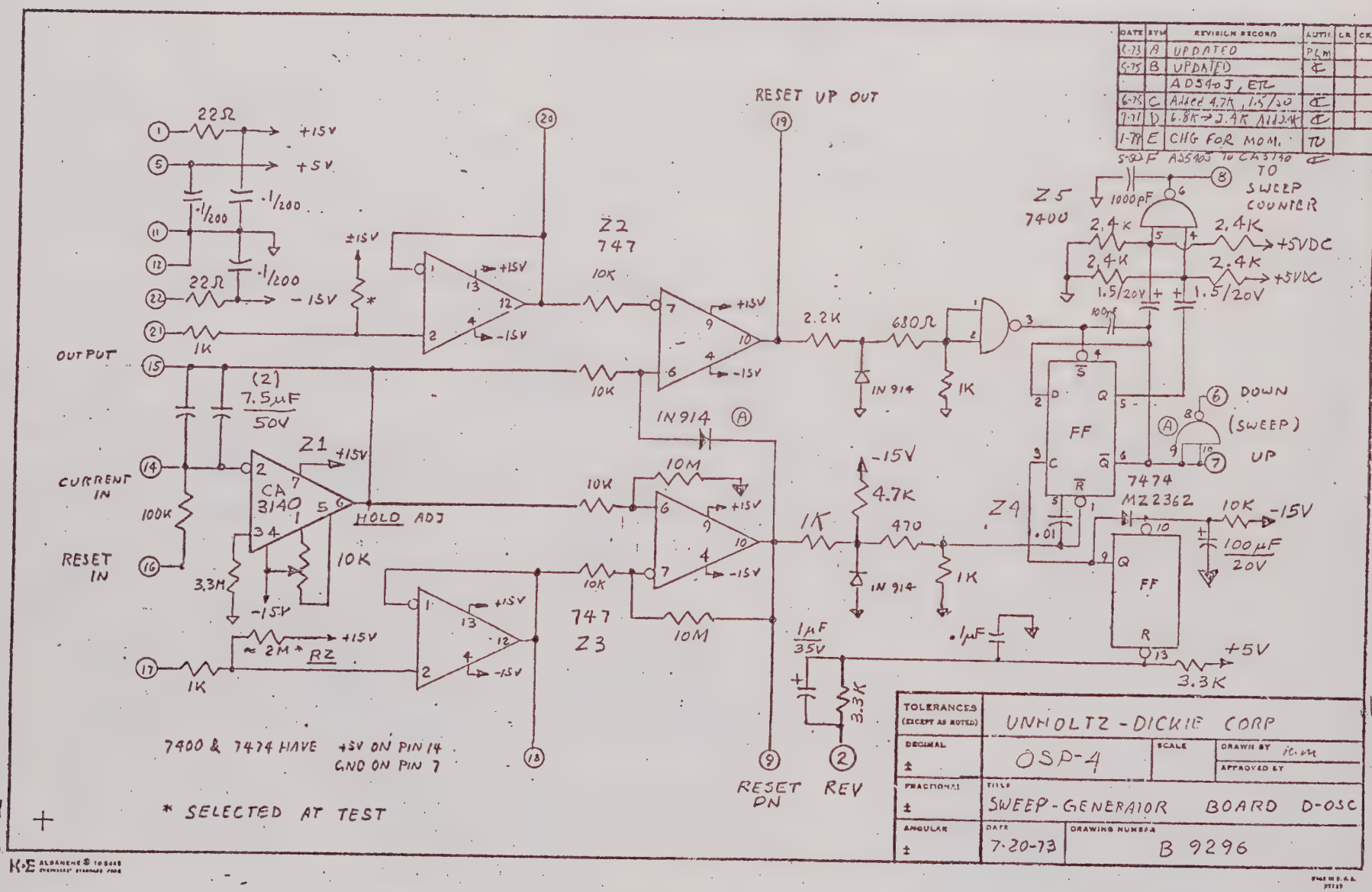
* 1% METAL FILM.

FIG 7.8

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSC-1 OSP-4 | SCALE | DRAWN BY TU / APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT C-OSC SWEEP SPEED CONTROL | | |
| ANGULAR ± | DATE 5-15-75 | DRAWING NUMBER A9298 | |

K&E CRYSTALENE ® 10 0405 ENGINEERS' STANDARD FORM

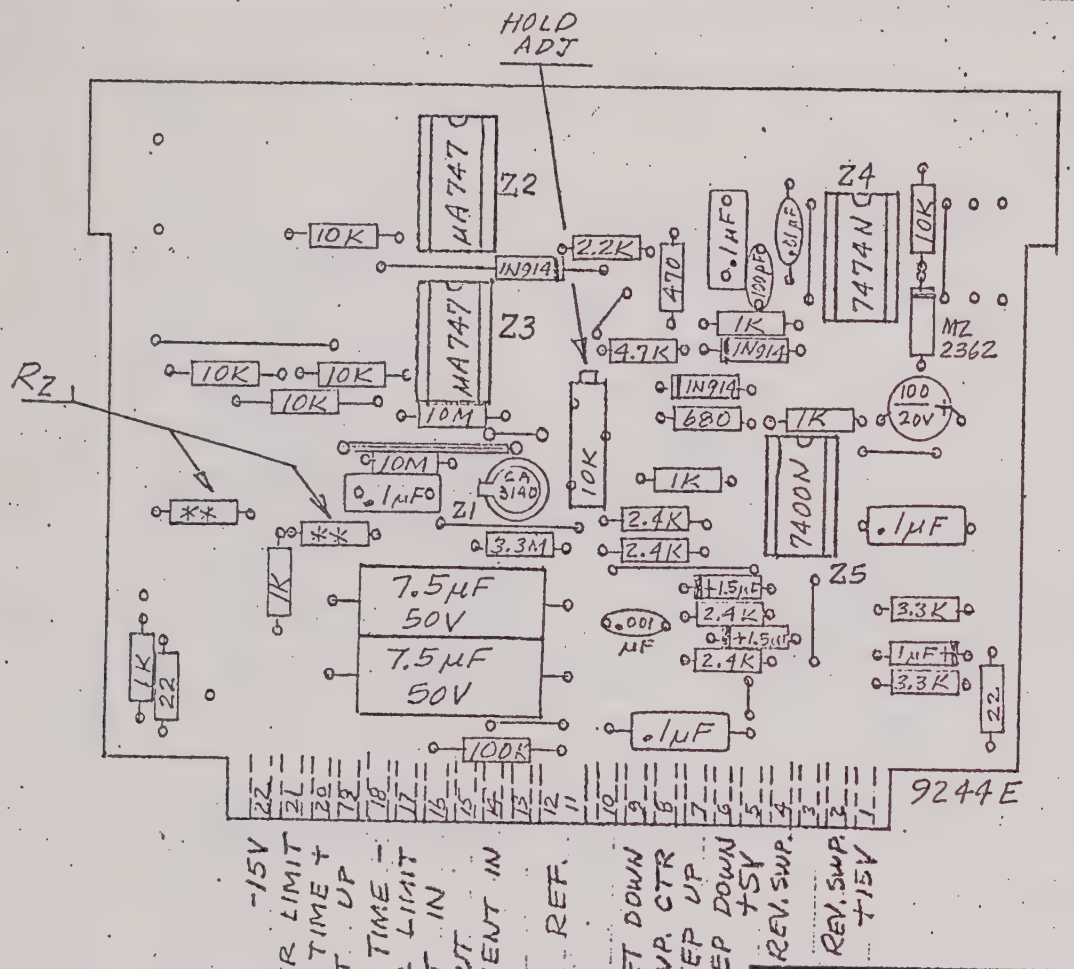
MADE IN U.S.A.




| DATE | SYM | REVISION RECORD | AUTH. | C.K. | C.K. |
|---|---|---|---|---|---|
| 1-73 | A | UPDATED | PLM | | |
| 6-75 | B | UPDATED | | | |
| | | AD540J, ETC | | | |
| 6-76 | C | Added 4.7K, 1.5/20 | | | |
| 9-77 | D | 6.8K→3.9K ADJ 3.9K | | | |
| 1-78 | E | CHG FOR MOM. | TU | | |
| 5-82 | F | AD540J TO CA3140 | | | |

| | | |
|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP | |
| DECIMAL ± | OSP-4 | SCALE / DRAWN BY PLM / APPROVED BY |
| FRACTIONAL ± | TITLE: SWEEP-GENERATOR BOARD D-OSC | |
| ANGULAR ± | DATE: 7-20-73 | DRAWING NUMBER: B 9296 |

FIG 7.9




| DATE | SYM | REVISION RECORD | AUTH | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | B | AD540J +10M | TU | | |
| 6-75 | C | 4.7K ADDED 1.5/20 | TC | | |
| 1-76 | D | 2.4K ADDED | TU | | |
| 5-79 | E | CKT. CHG 7A | TU | | |
| 6-80 | F | CHG AD510J TO CA3140 | I | | |

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSP-4 | SCALE 1 | DRAWN BY TU |
| | | | APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT D-OSC SWEEP GENERATOR | | |
| ANGULAR ± | DATE 5-10-79 | DRAWING NUMBER A 9299 | |

FIG 7.10

ALBANENE ® 10 5465
ENGINEERS' STANDARD FORM
MADE IN U.S.A.

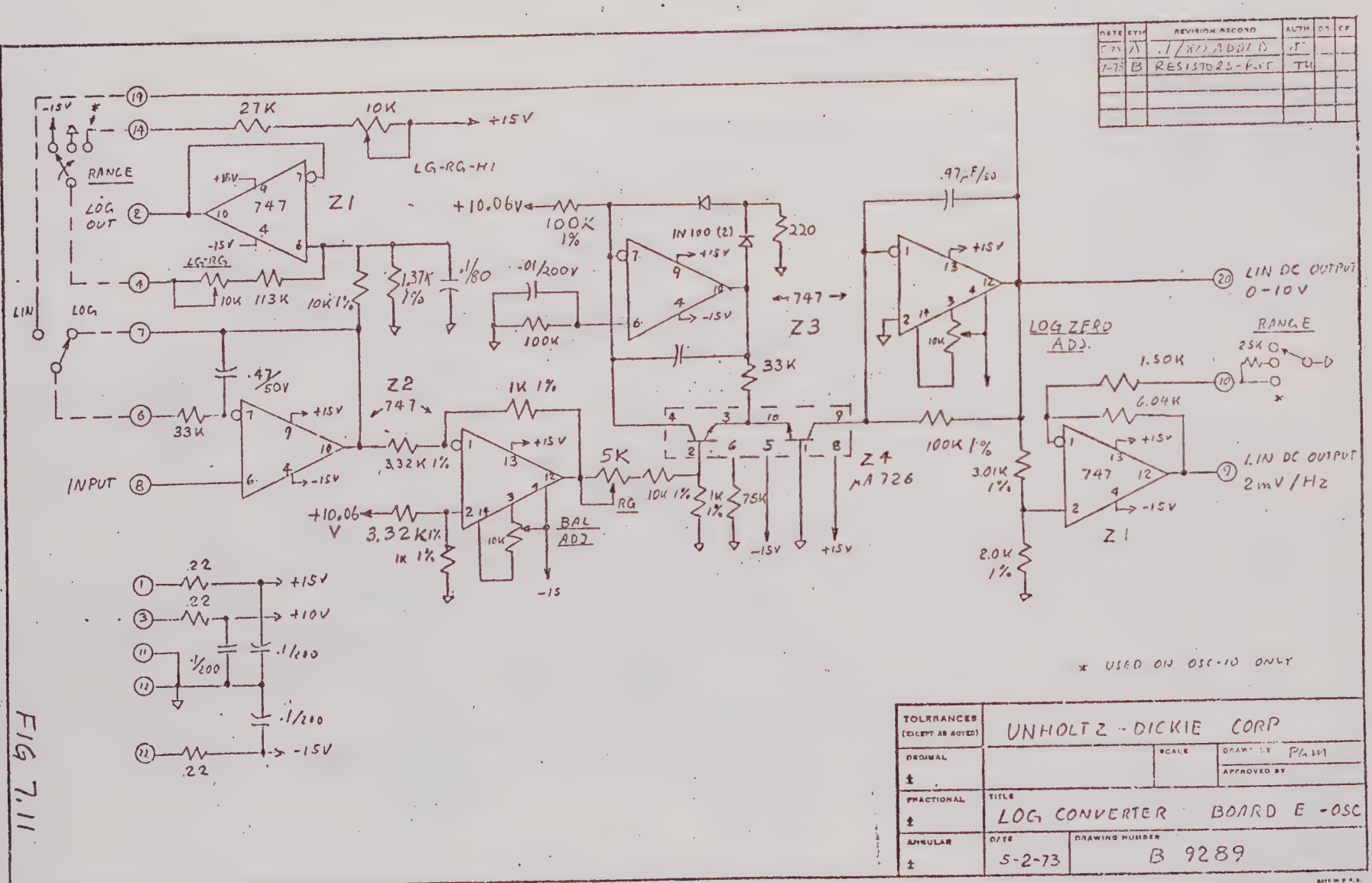
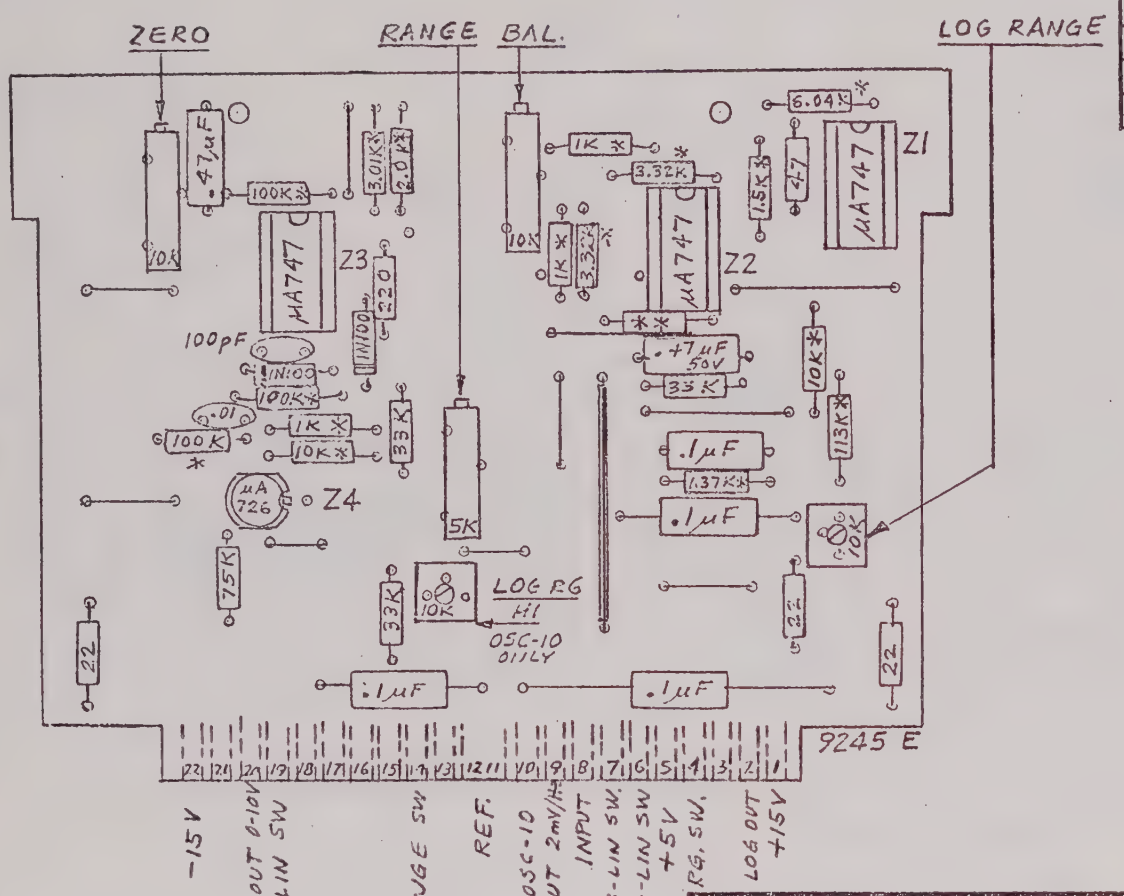

REVISION RECORD
DATE
BY
AUTH
DR
CK
A
B
RESISTORS
RANGE
LOG OUT
LIN
LOG
INPUT
LG-RG-HI
LG-RG
Z1
Z2
Z3
Z4
747
MA 726
27K
10K
+15V
-15V
100K 1%
IN 100 (2)
220
.47µF/50
33K
1K 1%
3.32K 1%
5K
RG
10K 1%
1K 1%
75K
BAL ADJ
1.37K 1%
.1/80
.01/200V
100K
10K 113K
.47/50V
+10.06V
LOG ZERO ADJ.
1.50K
6.04K
25K
100K 1%
3.01K 1%
2.0K 1%
LIN DC OUTPUT 0-10V
LIN DC OUTPUT 2mV/Hz
.22
.1/200
* USED ON OSC-10 ONLY
TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±
UNHOLTZ-DICKIE CORP
SCALE
DRAWN BY P/A
APPROVED BY
TITLE
LOG CONVERTER BOARD E -OSC
DATE 5-2-73
DRAWING NUMBER B 9289

FIG 7.11

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | A | NEW BOARD - 2 COMPS. | TU | | |
| 7-75 | B | 3.32K ⇒ 3.57K | | | |
| | | 2K POT ⇒ 5K POT | TU | | |
| | | 100K ⇒ 105K. | | | |
| 11-75 | C | 105K ⇒ 100K 3.57K ⇒ 3.32K | TU | | |




* 1% METAL FILM

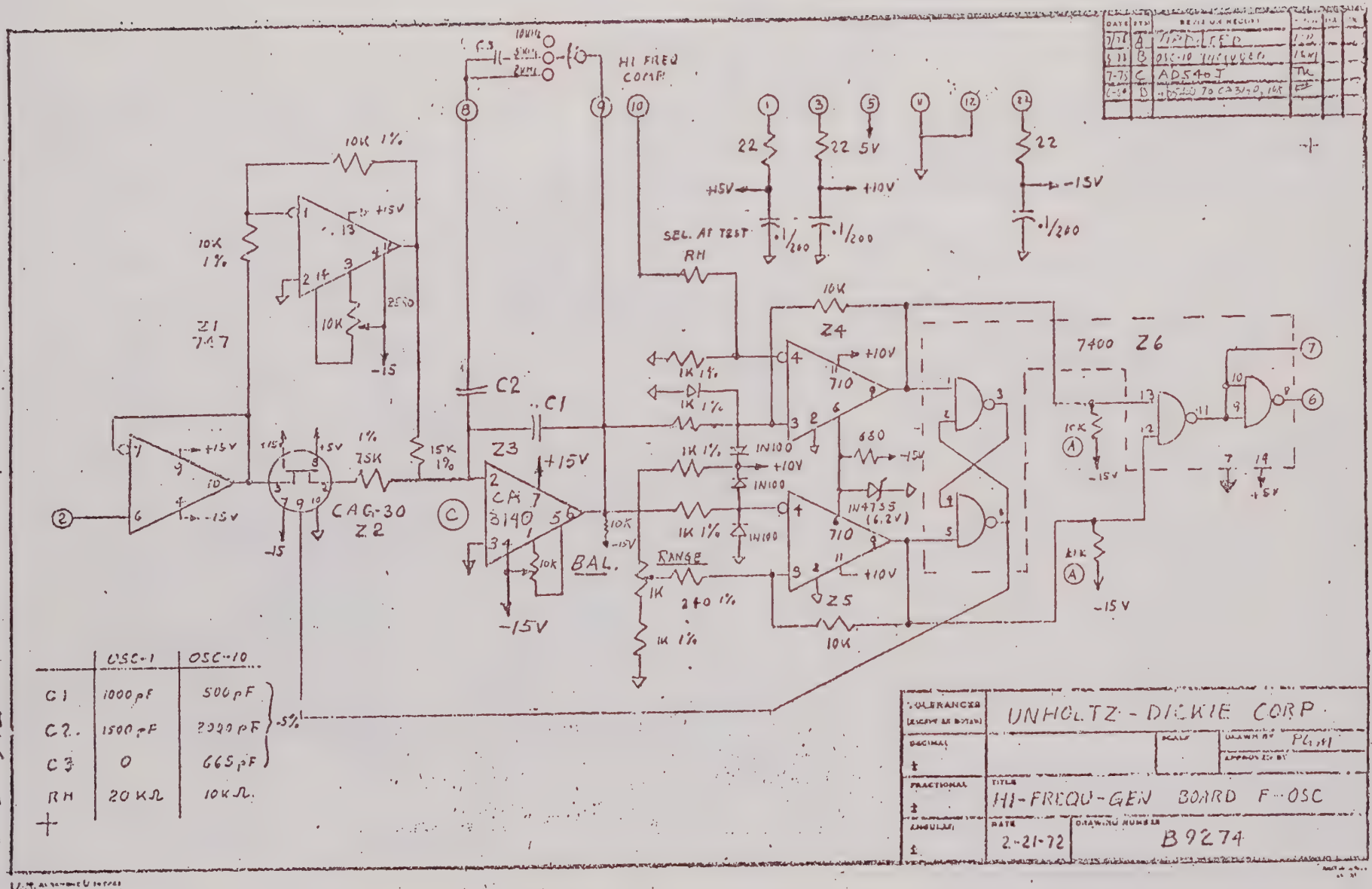
** FACTORY SELECT

FIG 7.12

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSC-1 OSP-4 | SCALE | DRAWN BY TU |
| | | | APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT E-OSC LOG CONVERTER | | |
| ANGULAR ± | DATE 5-15-75 | DRAWING NUMBER A9290 | |

K&E CRYSTALENE ® 10 5405 ENGINEERS' STANDARD FORM

MADE IN U. S. A.




| | OSC-1 | OSC-10 | |
|---|---|---|---|
| C1 | 1000 pF | 500 pF | |
| C2 | 1500 pF | 2000 pF | ±5% |
| C3 | 0 | 665 pF | |
| RH | 20 KΩ | 10 KΩ | |

| DATE | BY | REVISION RECORD | APP. | CK. |
|---|---|---|---|---|
| 7/71 | A | ADDED LED | | |
| 8 11 | B | 2SC-10 10K 1% ADDED | | |
| 7-73 | C | AD540 J | | |
| (-5* | D | ADDED TO C3 2.0, 10K | | |

UNHOLTZ-DICKIE CORP.

TOLERANCES (UNLESS OTHERWISE SPECIFIED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±

SCALE

DRAWN BY PL 1/71

APPROVED BY

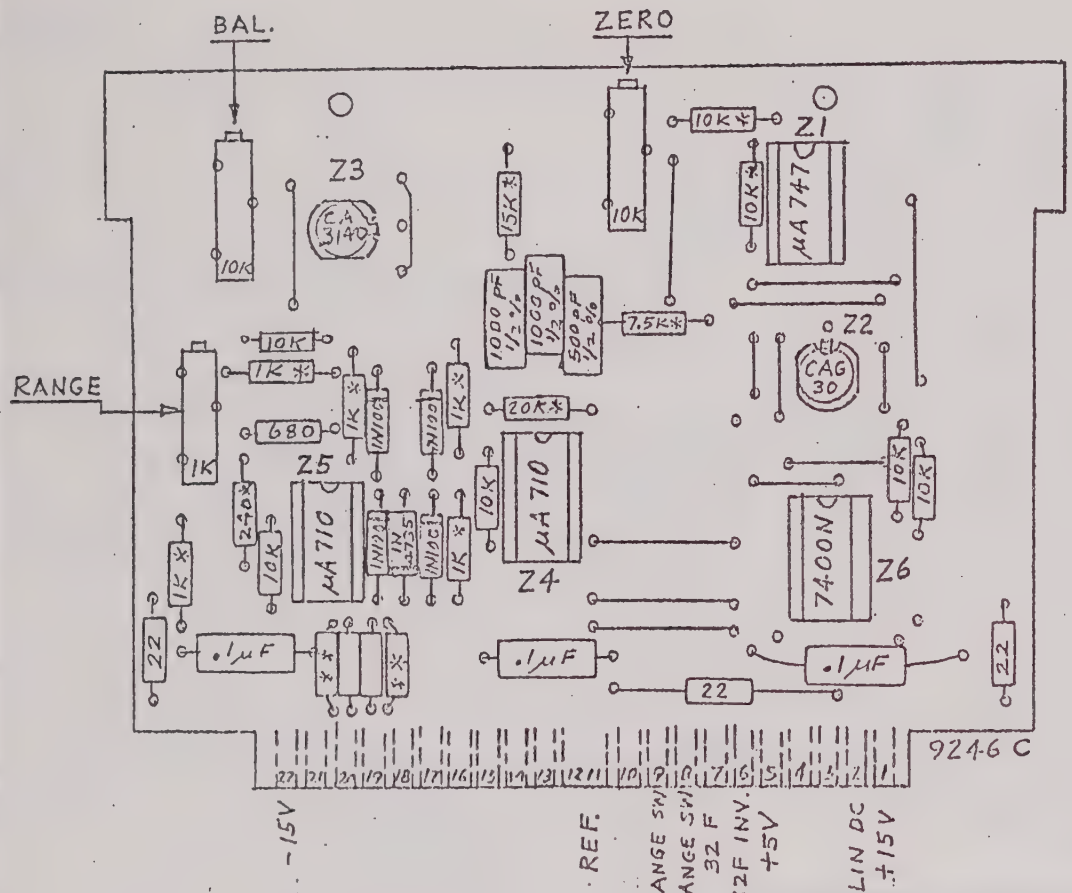
TITLE: HI-FREQU-GEN BOARD F-OSC

DATE 2-21-72

DRAWING NUMBER B9274

FIG 7.13

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | D | 23, SOCKETS CHGD | TU | | |
| 8-80 | E | ADS40T TO CA3140, 10K | TU | | |
| | | | | | |
| | | | | | |
| | | | | | |



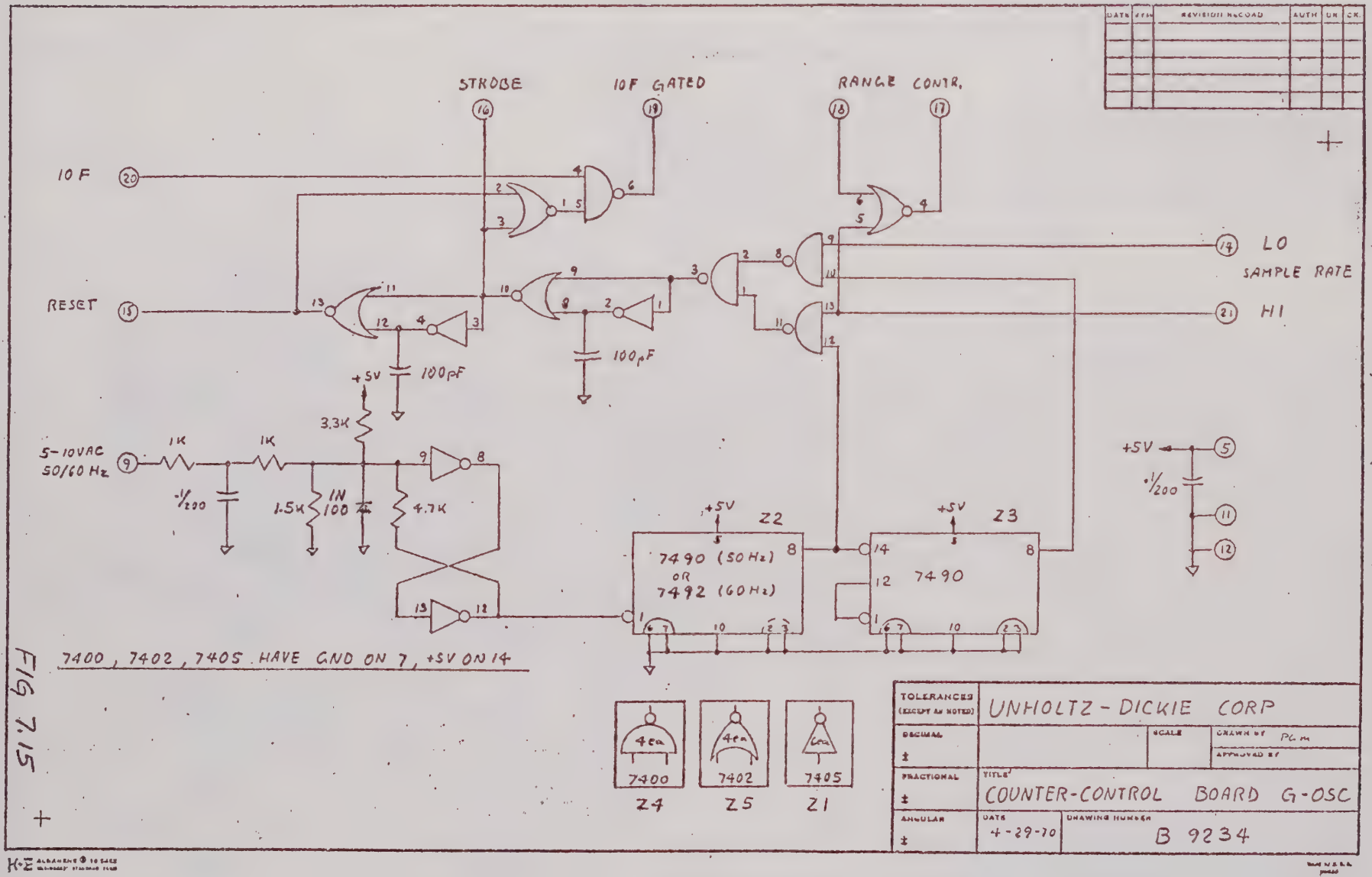

* 1% METAL FILM

* FACTORY SELECT

FIG 7.14

| | | |
|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | |
| DECIMAL ± | OSC-1 OSP-4 | SCALE: — DRAWN BY: TU APPROVED BY: |
| FRACTIONAL ± | TITLE: COMPONENT LAYOUT F-OSC HIGH FREQ. GENERATOR | |
| ANGULAR ± | DATE: 5-14-75 | DRAWING NUMBER: A 9275 |

MADE IN U.S.A.

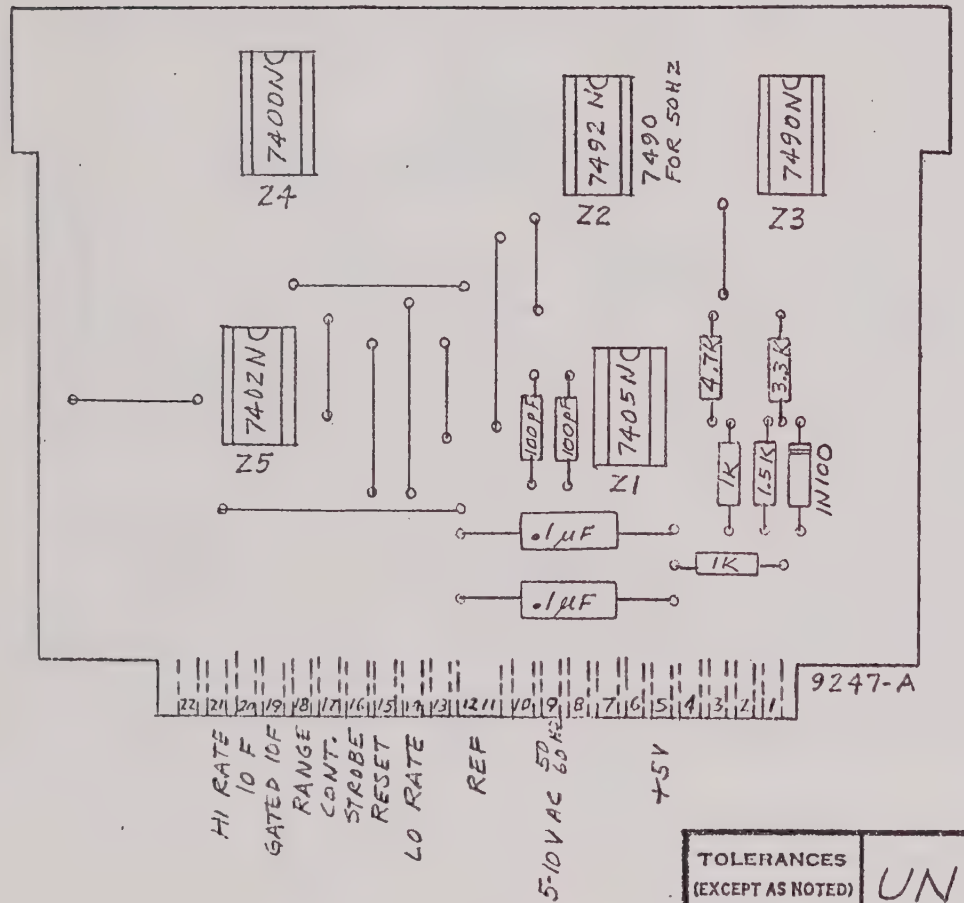



| DATE | BY | REVISION RECORD | AUTH | LR | CK |
|---|---|---|---|---|---|
| | | | | | |

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP | | |
| DECIMAL ± | | SCALE | DRAWN BY PL M<br>APPROVED BY |
| FRACTIONAL ± | TITLE: COUNTER-CONTROL BOARD G-OSC | | |
| ANGULAR ± | DATE 4-29-70 | DRAWING NUMBER B 9234 | |

Fig 7.15

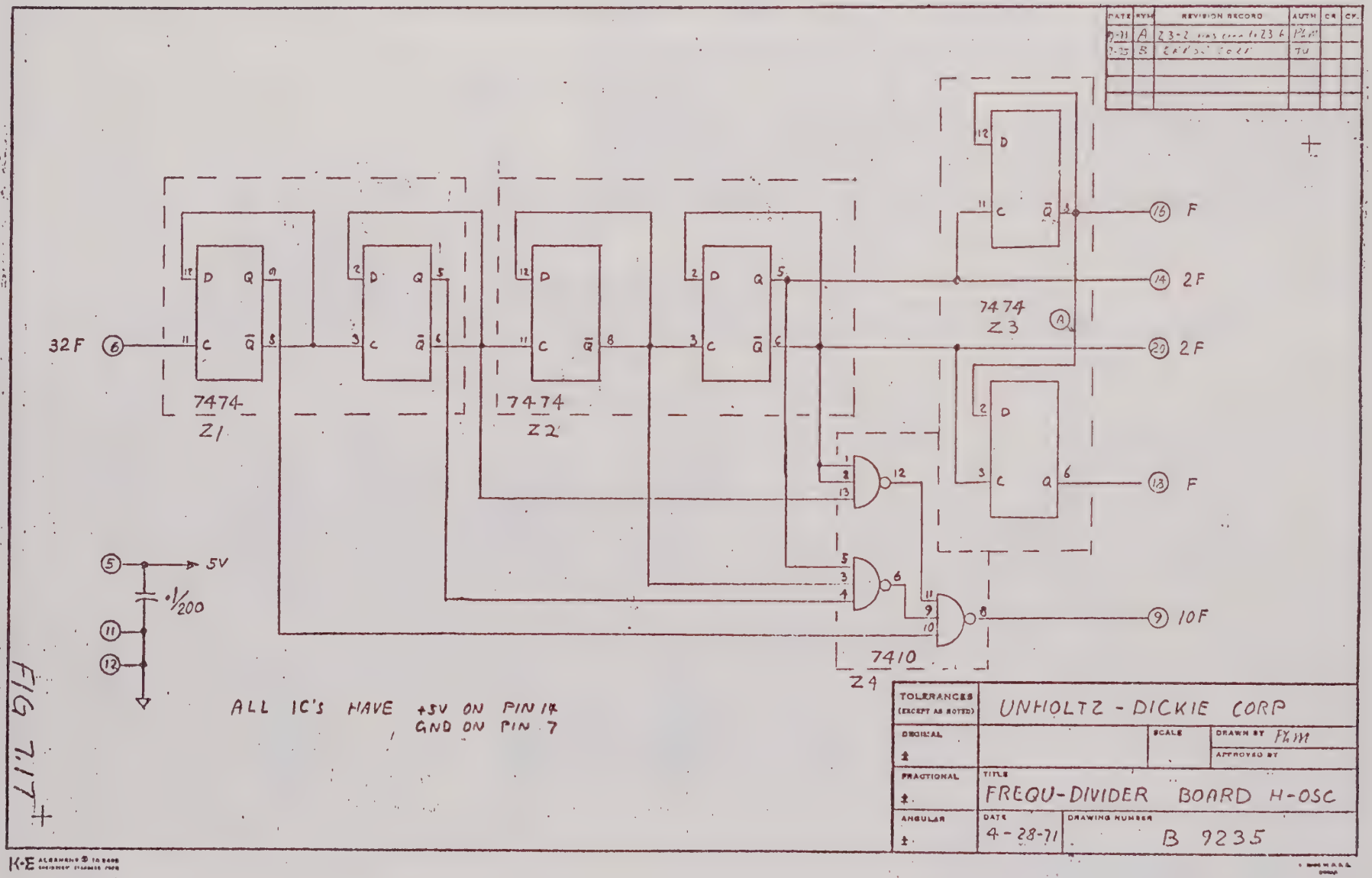
| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 5-15 | B | BOARD DIM. CHGD. | TU | | |
| | | IN3122 → IN100 | TU | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |




| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSC-1<br>OSP-4 | SCALE | DRAWN BY TU<br>APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT<br>G-OSC COUNTER CONTROL | | |
| ANGULAR ± | DATE 5-15-75 | DRAWING NUMBER A9261 | |

FIG 7.16

CRYSTALENE ® 10 5465
ENGINEERS' STANDARD FORM
MADE IN U.S.A.


32F
7474
Z1
7474
Z2
7474
Z3
7410
Z4
16 F
14 2F
20 2F
13 F
9 10F
5V
.1/200
ALL IC'S HAVE +5V ON PIN 14
GND ON PIN 7
UNHOLTZ - DICKIE CORP
FREQU-DIVIDER BOARD H-OSC
4-28-71
B 9235
Fig 7.17

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | A | BOARD SIZE CHGD | TU | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

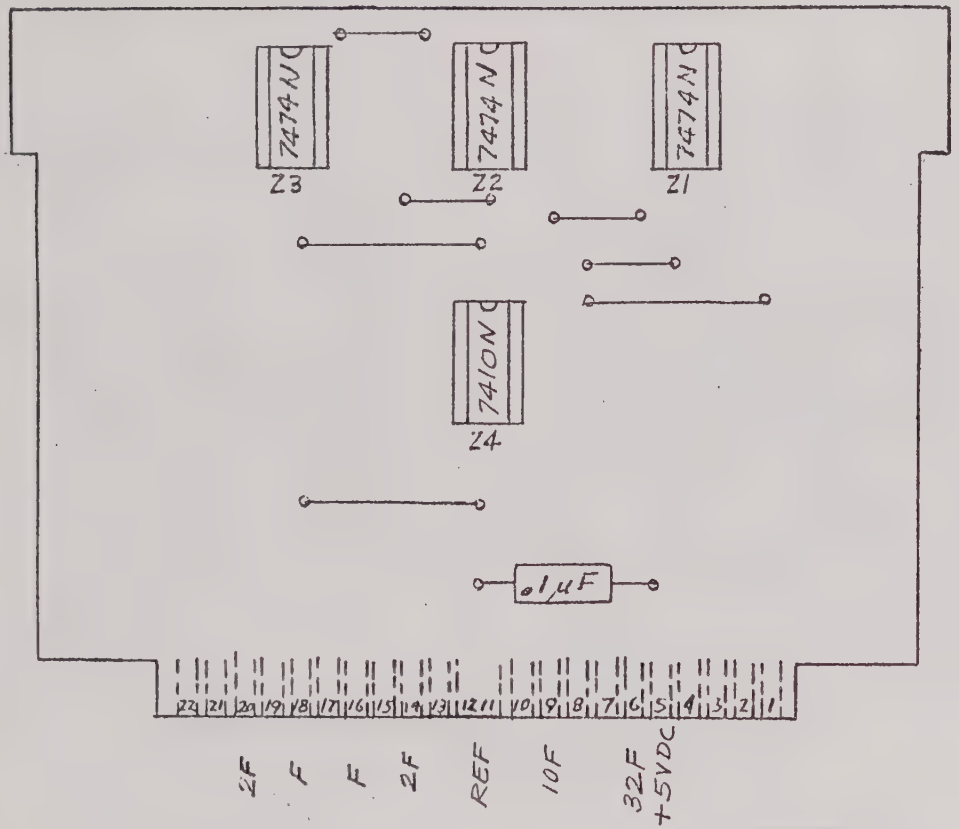



FIG. 7.18

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSC-1<br>OSP-4 | SCALE | DRAWN BY TU<br>APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT<br>H-OSC FREQUENCY DIVIDER | | |
| ANGULAR ± | DATE 5-15-75 | DRAWING NUMBER A9262 | |

M&E CRYSTALENE ® 10 5465

MADE IN U.S.A.

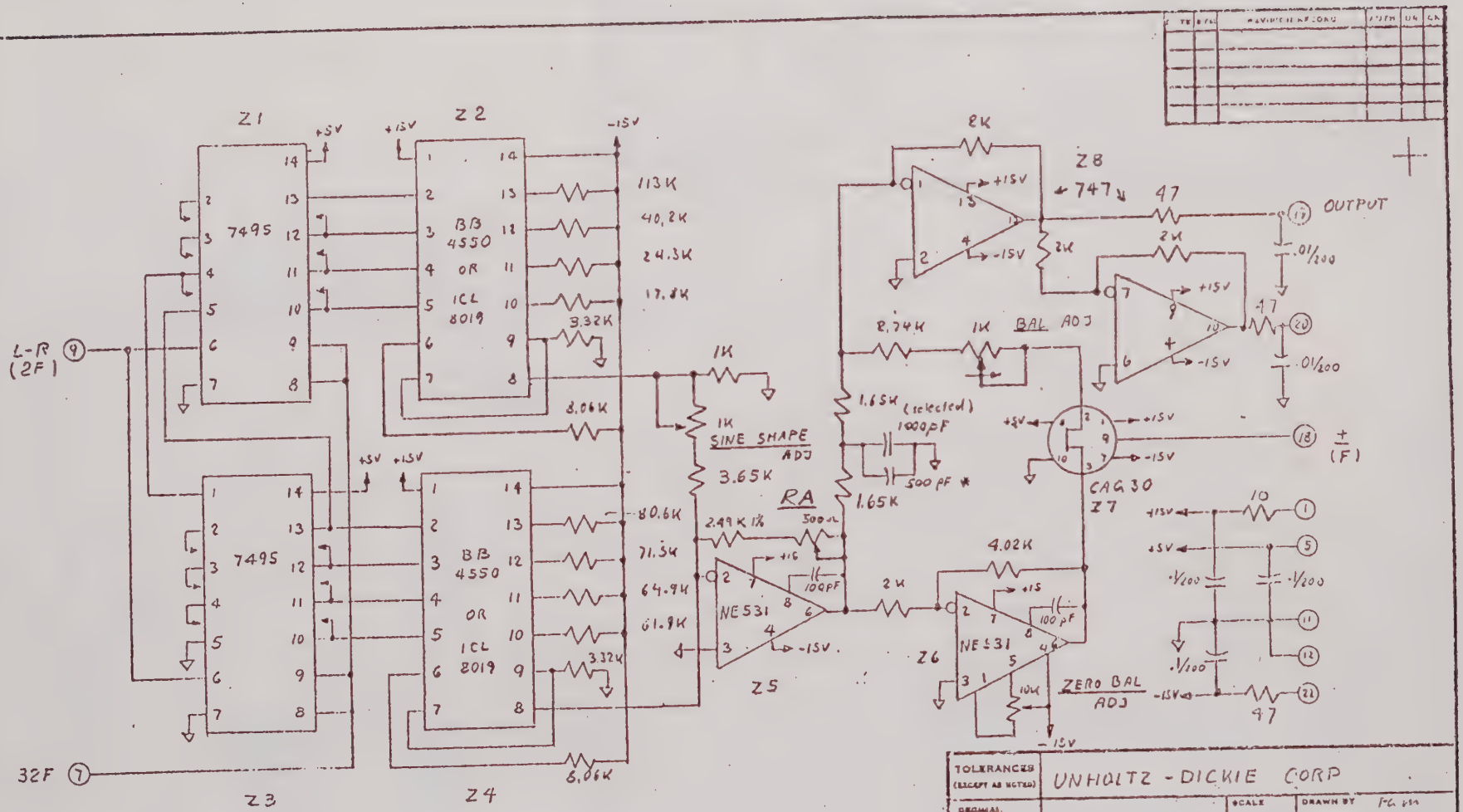

Z1
Z2
+5V
+15V
-15V
7495
BB 4550 OR ICL 8019
113K
40.2K
24.3K
17.8K
3.32K
8.06K
L-R (2F)
9
1K
1K SINE SHAPE ADJ
3.65K
RA
500Ω
2.49K 1%
80.6K
71.5K
64.9K
61.9K
3.32K
6.06K
32F
7
Z3
Z4
Z5
NE531
100pF
+15
-15V
2K
Z6
4.02K
100 pF
10K
ZERO BAL ADJ
-15V
Z8
747
8K
2K
47
OUTPUT
17
.01/100
2K
8.74K
1K BAL ADJ
47
20
.01/100
1.65K (selected)
1000pF
500 pF *
+5V
+15V
-15V
18
± (F)
CAG30
Z7
10
1
5
11
12
21
.1/100
.1/100
.1/100
47
* THIS VALUE MAY BE CHANGED AT TEST
TOLERANCES (EXCEPT AS NOTED)
DECIMAL ±
FRACTIONAL ±
ANGULAR ±
UNHOLTZ - DICKIE CORP
SCALE
DRAWN BY
APPROVED BY
TITLE
SINE GENERATOR BOARD 1-OSC
DATE
3-14-73
DRAWING NUMBER
B9284

Fig 7.19

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | A | BOARD SIZE CHGD | TU | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

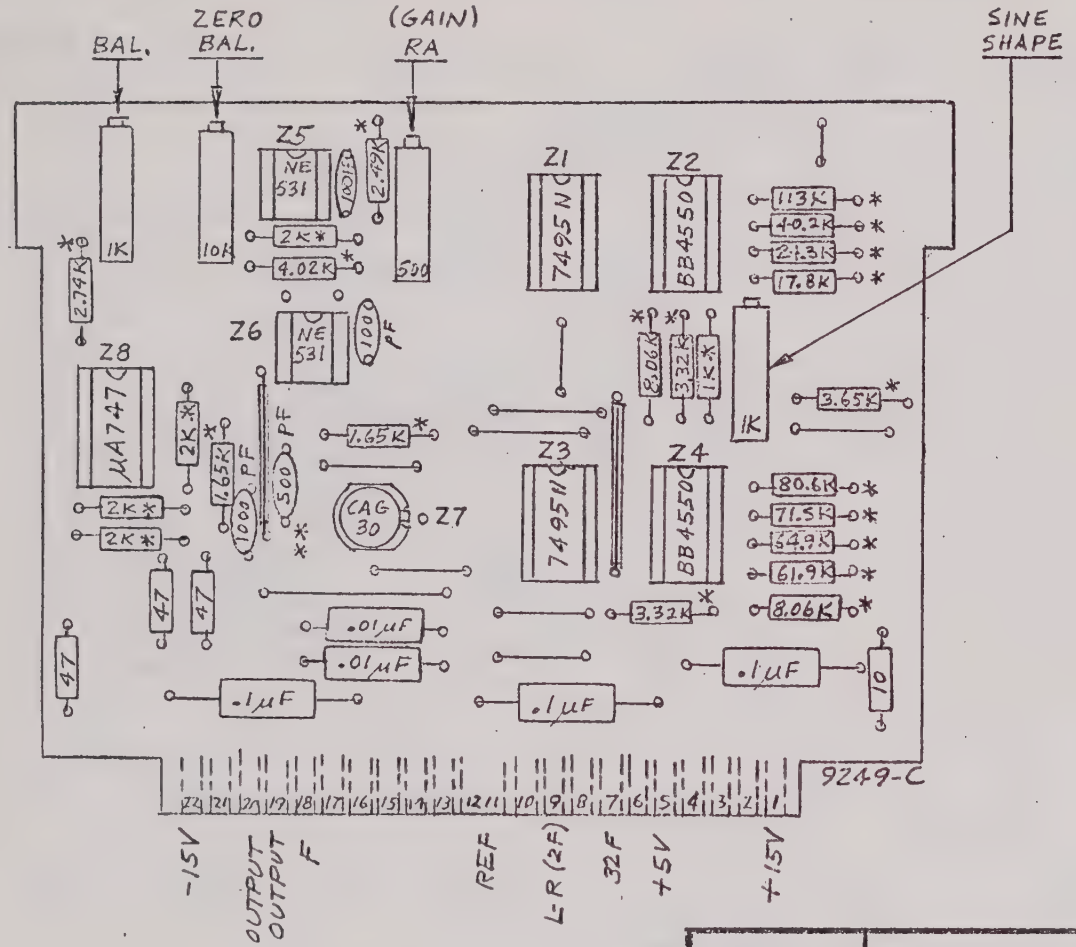


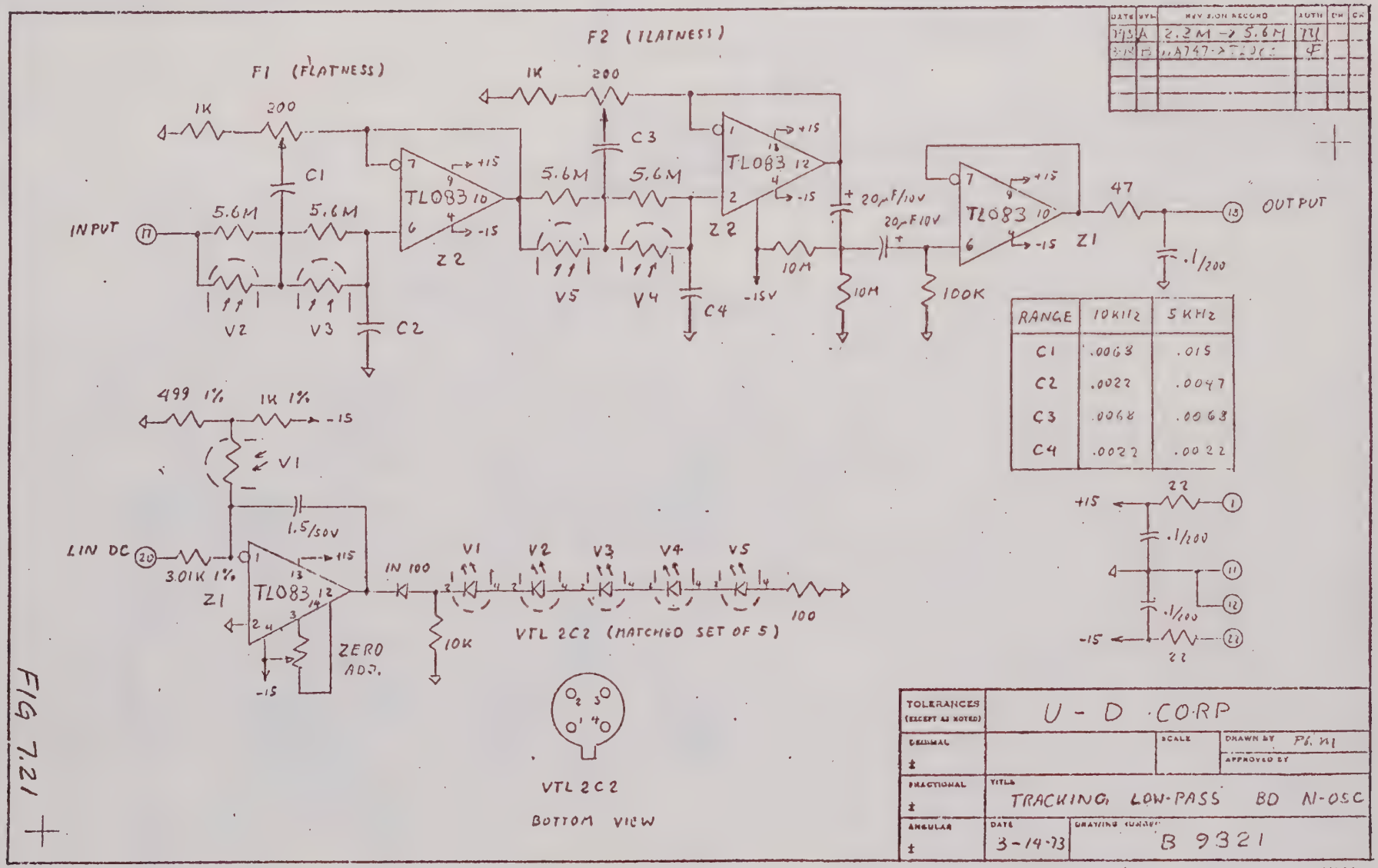

FIG 7.20

* 1% METAL FILM
** CAP. VALUE ADJUSTED AT FACTORY

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSC-1 OSP-4 | SCALE | DRAWN BY TU<br>APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT I-OSC SINE GENERATOR | | |
| ANGULAR ± | DATE 5-16-75 | DRAWING NUMBER A9286 | |

CRYSTALENE ® 10-5465 ENGINEERS' STANDARD FORM

MADE IN U.S.A.



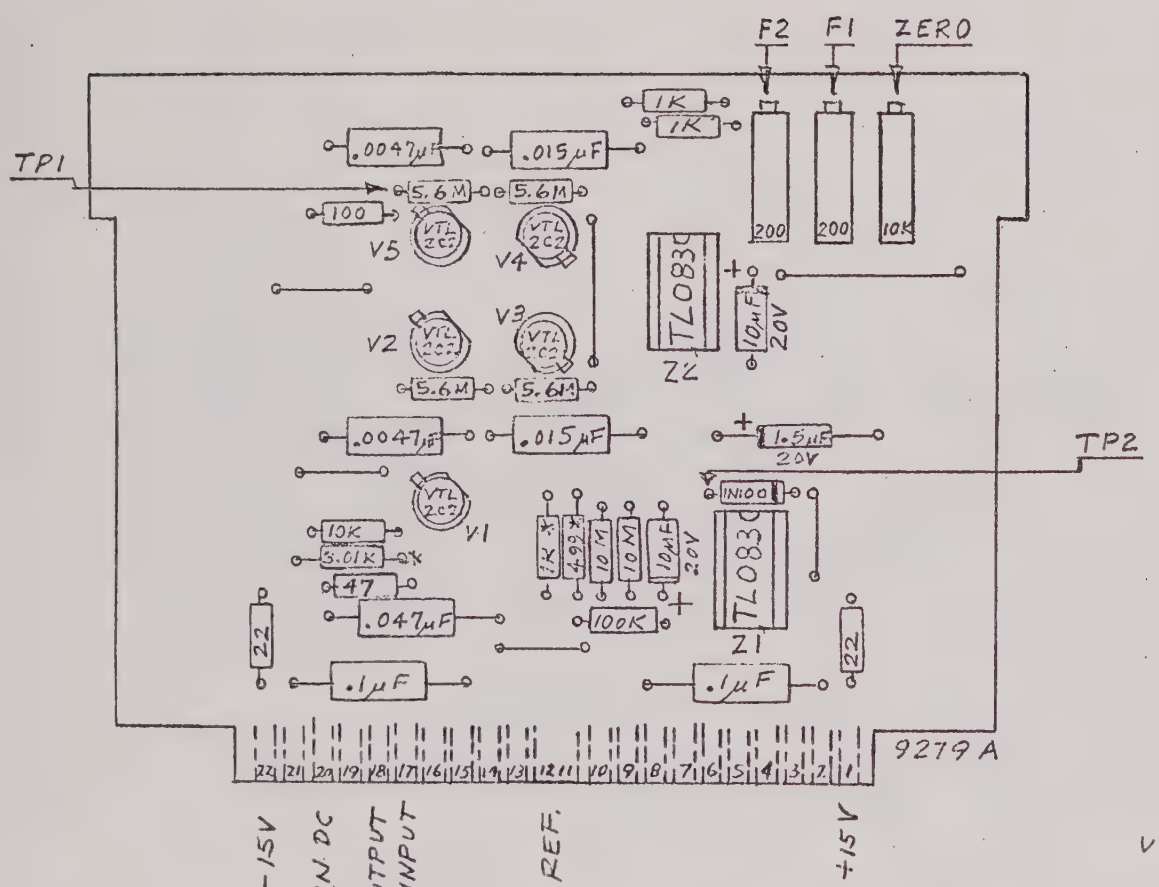

| RANGE | 10KHz | 5KHz |
|---|---|---|
| C1 | .0063 | .015 |
| C2 | .0022 | .0047 |
| C3 | .0068 | .0068 |
| C4 | .0022 | .0022 |

| DATE | REVISION RECORD | AUTH |
|---|---|---|
| 3-13 | A 2.2M → 5.6M | TM |
| 3-14 | B ADD A747 → TL083 | TM |

FIG 7.21

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | U - D CORP | | |
| DECIMAL ± | | SCALE | DRAWN BY PS. VI |
| | | | APPROVED BY |
| FRACTIONAL ± | TITLE TRACKING LOW-PASS BD N-OSC | | |
| ANGULAR ± | DATE 3-14-73 | DRAWING NUMBER B 9321 | |

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | A | BOARD SIZE CHGD | TU | | |
| 6-75 | B | (4) 2.2M ⇒ 5.6M | TU | | |
| 3-78 | C | μA747 ⇒ TL083 | | | |
| | | | | | |
| | | | | | |



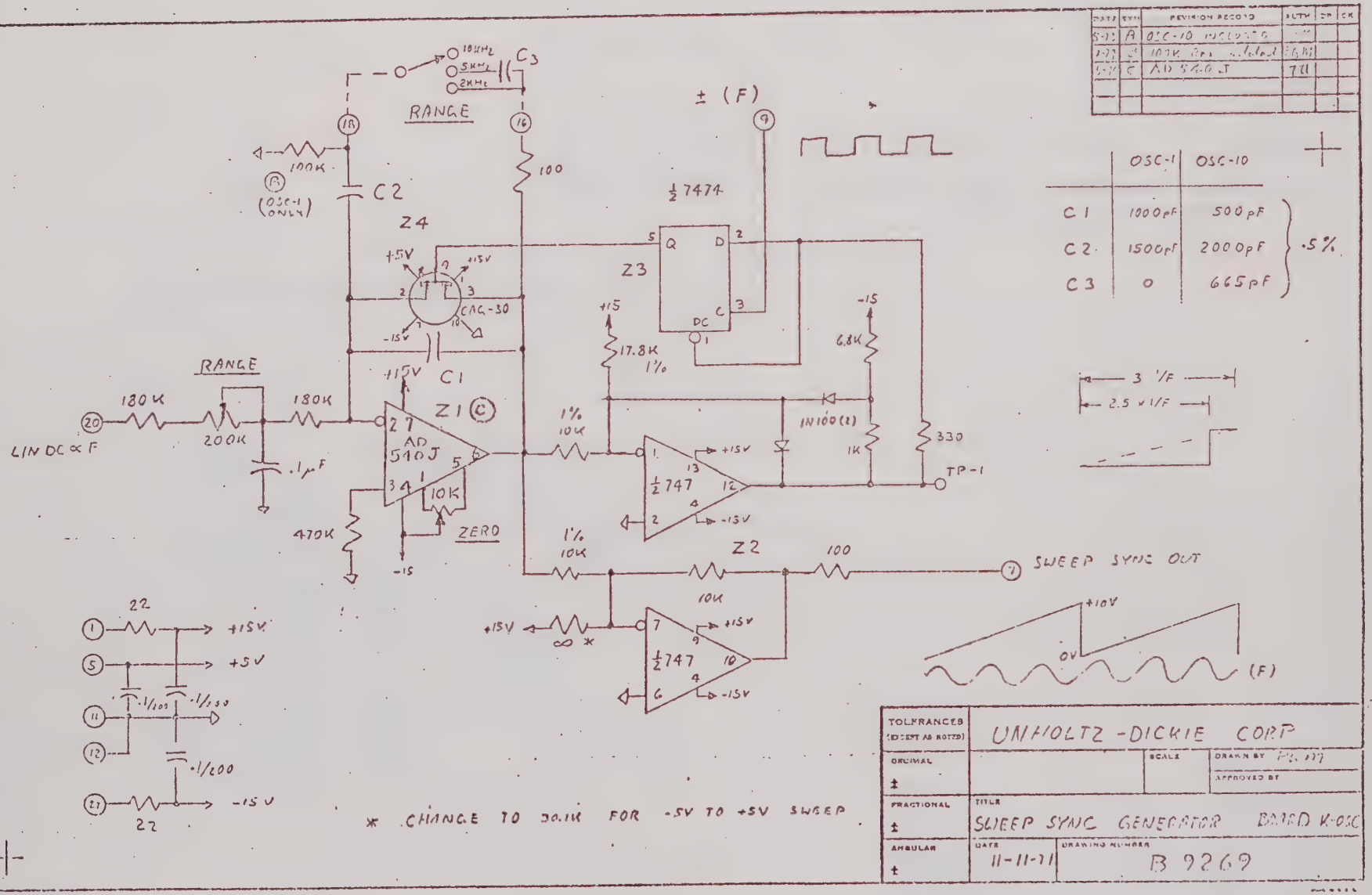

VTL 2C2 - MATCHED SET

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSC-1<br>OSP-4 | SCALE | DRAWN BY TU<br>APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT<br>N-OSC TRACKING LO-PASS | | |
| ANGULAR ± | DATE 5-16-75 | DRAWING NUMBER A9322 | |

FIG 7.22

K&E CRYSTALENE ® 10 5465 ENGINEERS' STANDARD FORM

MADE IN U.S.A.



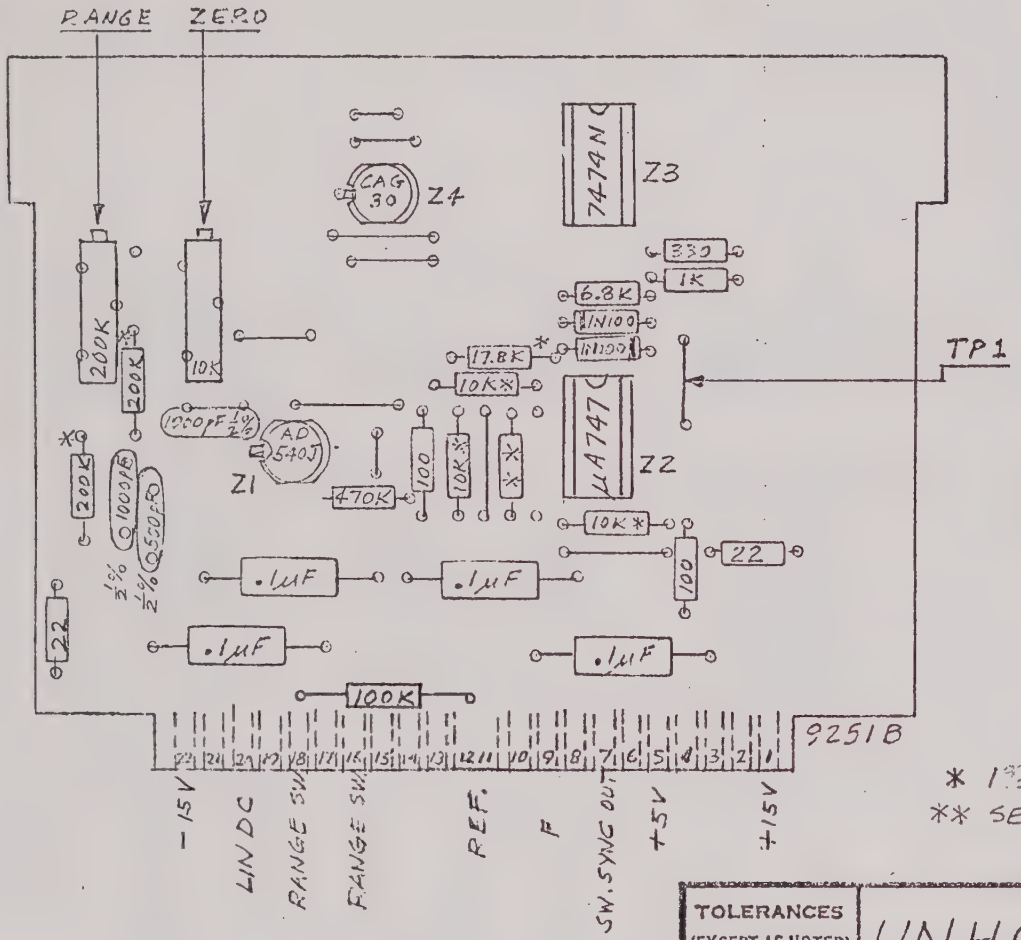

| DATE | SYM | REVISION RECORD | ALTH | DR | CK |
|---|---|---|---|---|---|
| 5-12 | A | OSC-10 included | | | |
| 1-73 | B | 100K Pot added | GM | | |
| 4-73 | C | AD 540 J | TH | | |

| | OSC-1 | OSC-10 | |
|---|---|---|---|
| C1 | 1000pF | 500pF | ·5% |
| C2 | 1500pF | 2000pF | |
| C3 | 0 | 665pF | |

| | |
|---|---|
| TOLERANCES (UNLESS AS NOTED) | UNIHOLTZ-DICKIE CORP |
| DECIMAL ± | SCALE |
| FRACTIONAL ± | TITLE: SWEEP SYNC GENERATOR BOARD K-OSC |
| ANGULAR ± | DATE 11-11-71 DRAWING NUMBER B 9269 |

FIG 7.23

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | A | BOARD SIZE CHGD | TU | | |
| | | ADJ 40T ADDED | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |



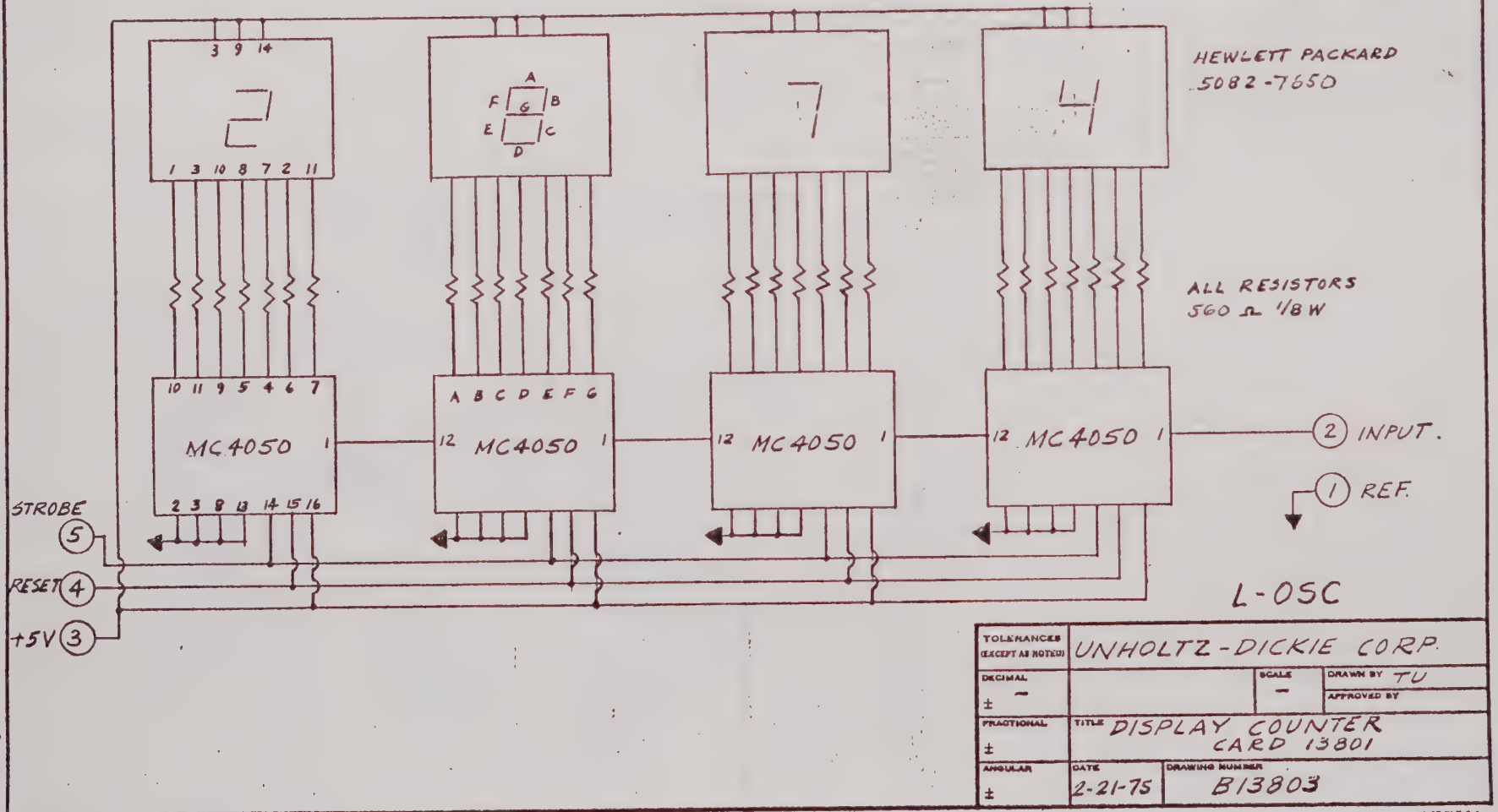

* 1% METAL FILM
** SELECTED

FIG 7.24

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSC-1 OSP-4 | SCALE | DRAWN BY TU / APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT K-OSC SWEEP SYNC GENERATOR | | |
| ANGULAR ± | DATE 5-16-75 | DRAWING NUMBER A9265 | |

Bliss CRYSTALENE © 10 5405
MADE IN U.S.A.

| DATE | SYM | REVISION RECORD | AUTH | DR. | CK. |
|---|---|---|---|---|---|
| | | | | | |




HEWLETT PACKARD
5082-7650

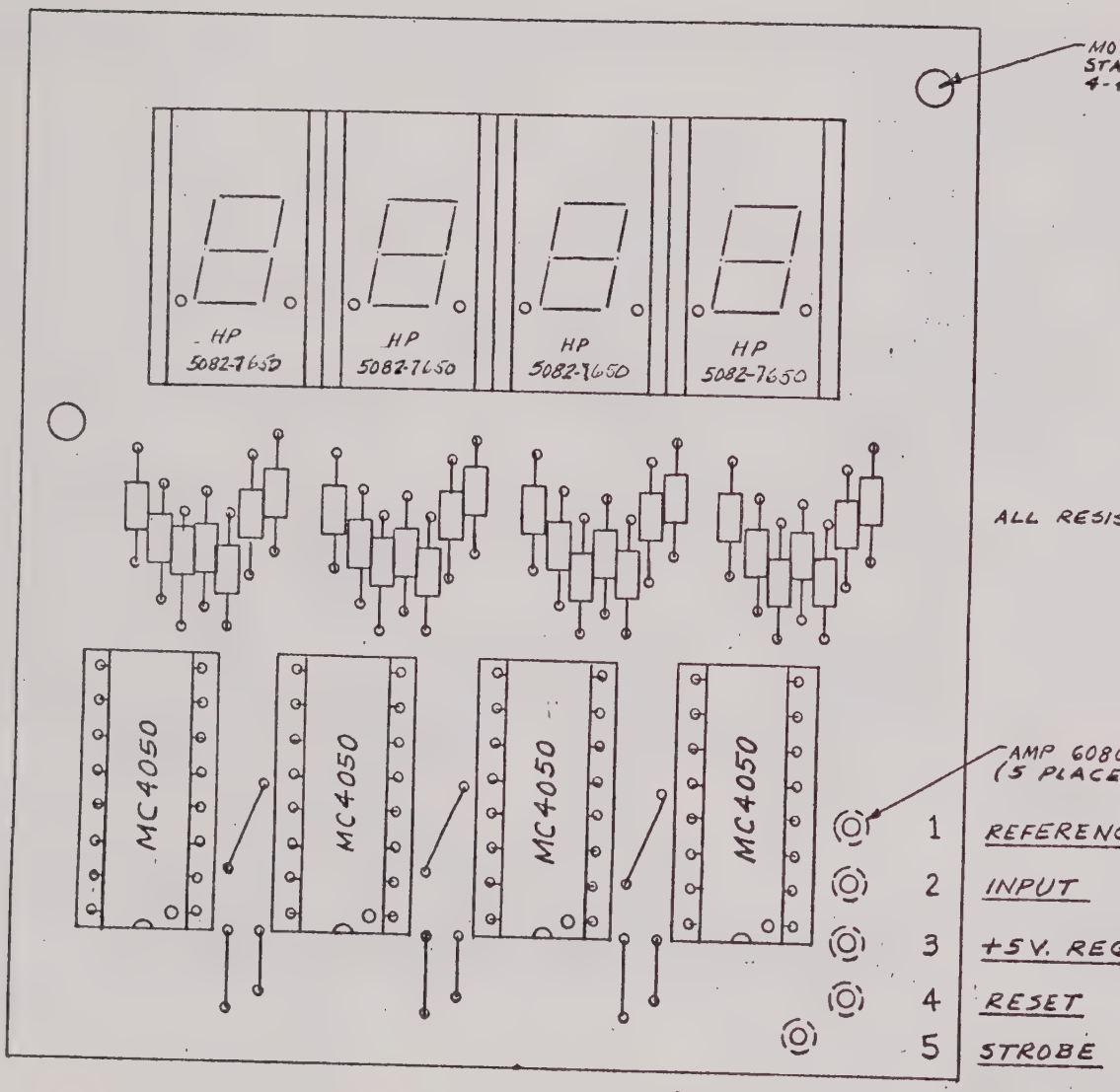
ALL RESISTORS
560 Ω 1/8 W

L-OSC

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± — | | SCALE — | DRAWN BY TU |
| | | | APPROVED BY |
| FRACTIONAL ± | TITLE DISPLAY COUNTER CARD 13801 | | |
| ANGULAR ± | DATE 2-21-75 | DRAWING NUMBER B13803 | |

Fig 7.25

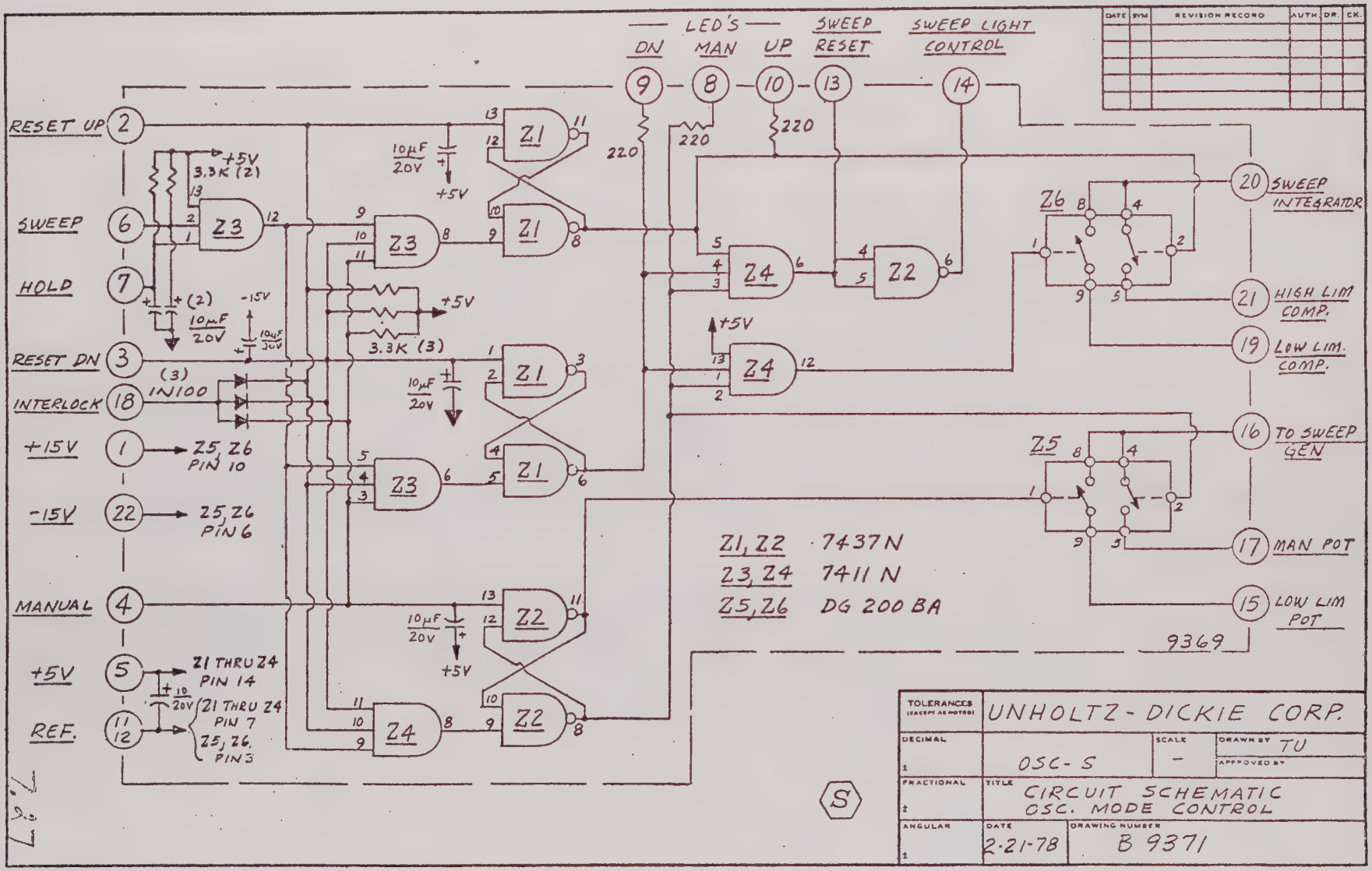
K-E




L-OSC

| | |
|---|---|
| TOLERANCES UNLESS NOTED | UNHOLTZ-DICKIE CORP |
| DECIMAL ± | OSP-4 |
| SCALE | |
| DRAWN BY TU | |
| APPROVED BY | |
| FRACTIONAL ± | TITLE DISPLAY COUNTER COMPONENT LAYOUT |
| ANGULAR ± | DATE 2-21-75 |
| DRAWING NUMBER | C13802 |

FIG 726

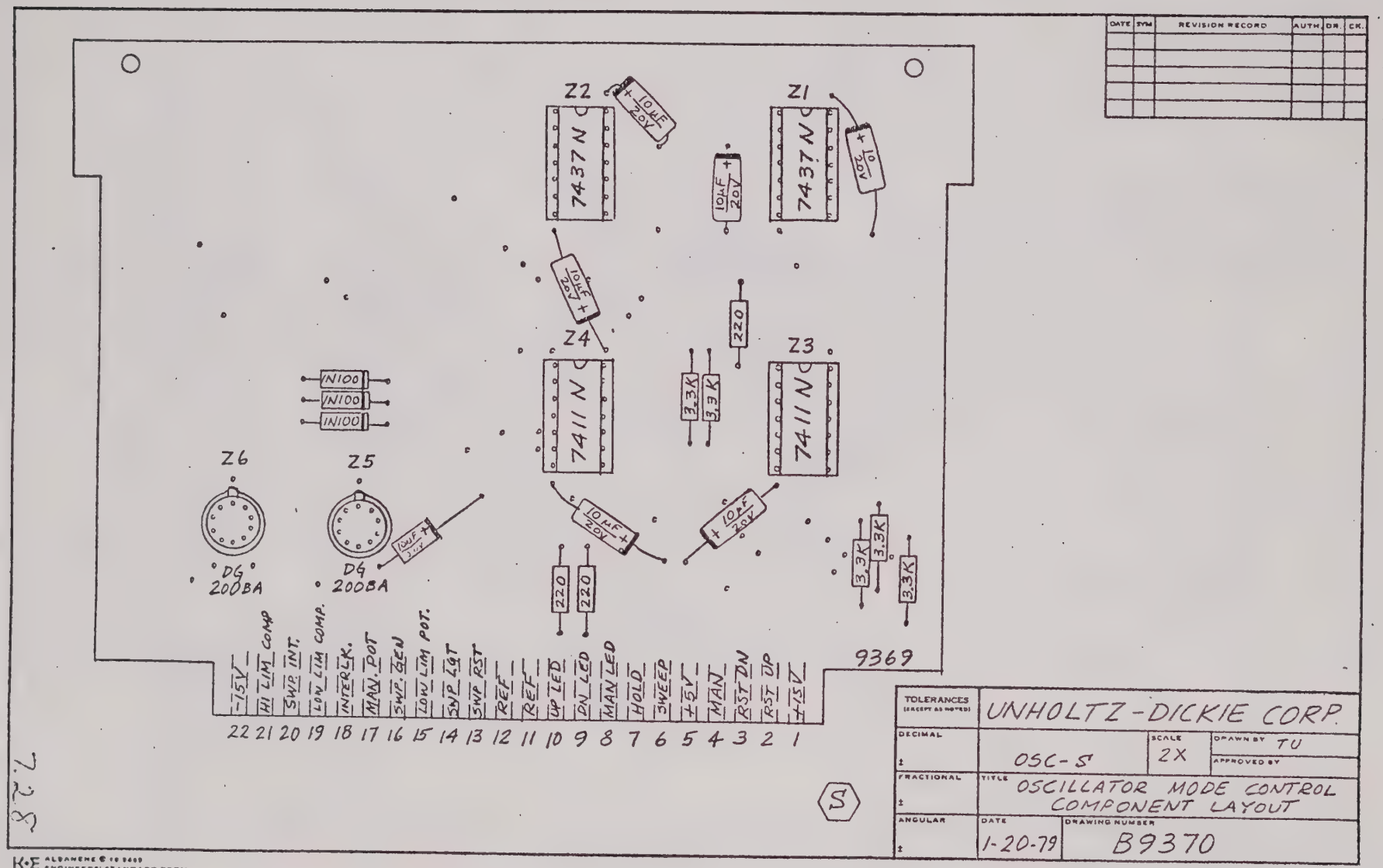



| DATE | BY | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| | | | | | |

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSC-S | SCALE – | DRAWN BY TU / APPROVED BY |
| FRACTIONAL ± | TITLE CIRCUIT SCHEMATIC OSC. MODE CONTROL | | |
| ANGULAR ± | DATE 2-21-78 | DRAWING NUMBER B 9371 | |

K·E ALBANENE © 18 8469 ENGINEERS' STANDARD FORM

MADE IN U.S.A.




| DATE | BY | REVISION RECORD | AUTH | DR. | CK. |
|---|---|---|---|---|---|
| | | | | | |

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSC-S | SCALE 2X | DRAWN BY TU |
| | | | APPROVED BY |
| FRACTIONAL ± | TITLE OSCILLATOR MODE CONTROL COMPONENT LAYOUT | | |
| ANGULAR ± | DATE 1-20-79 | DRAWING NUMBER B9370 | |

7.28

K·E ALBANENE © 10 2400 ENGINEERS' STANDARD FORM

MADE IN U.S.A.

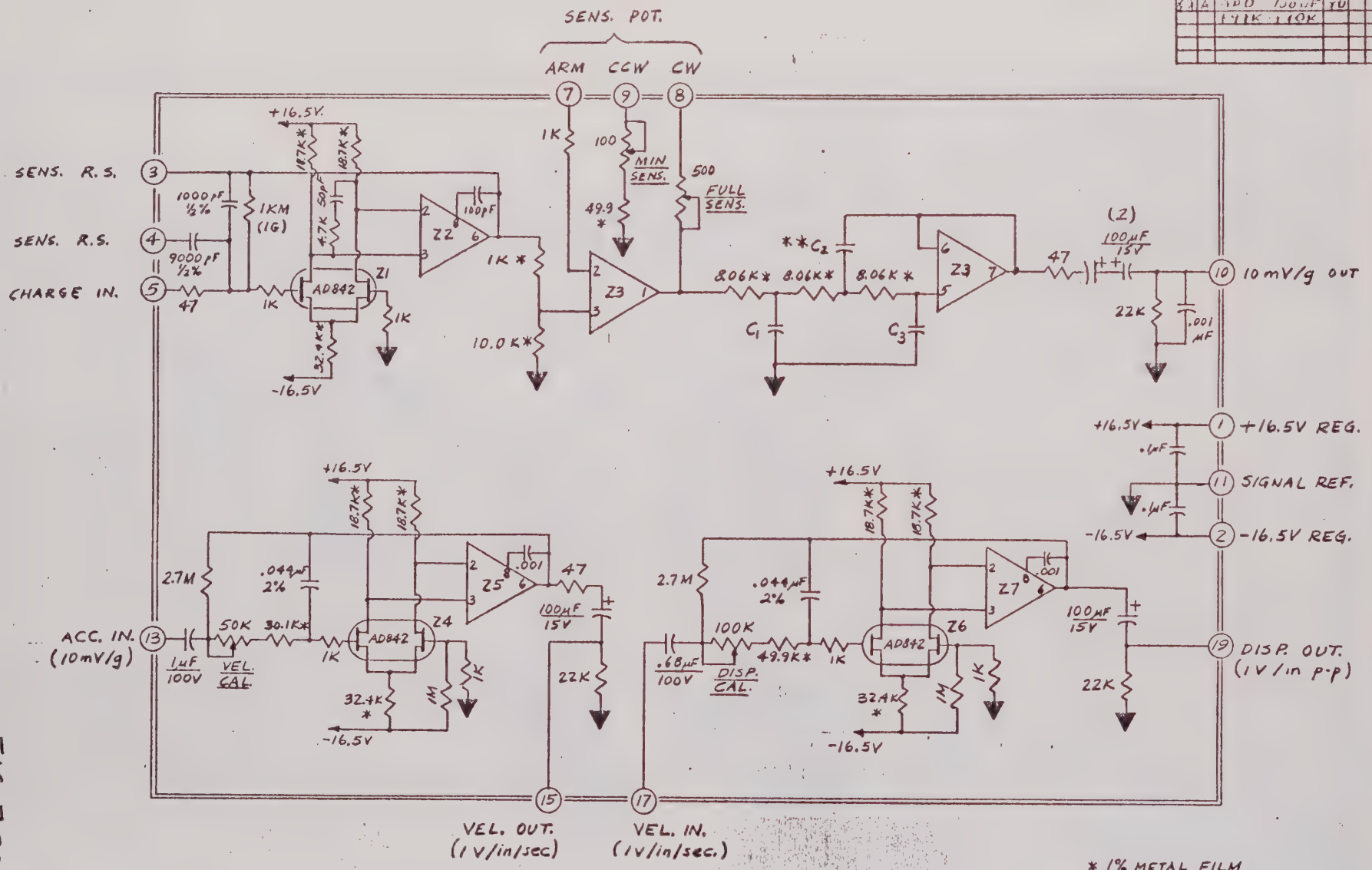



FIG 7.29

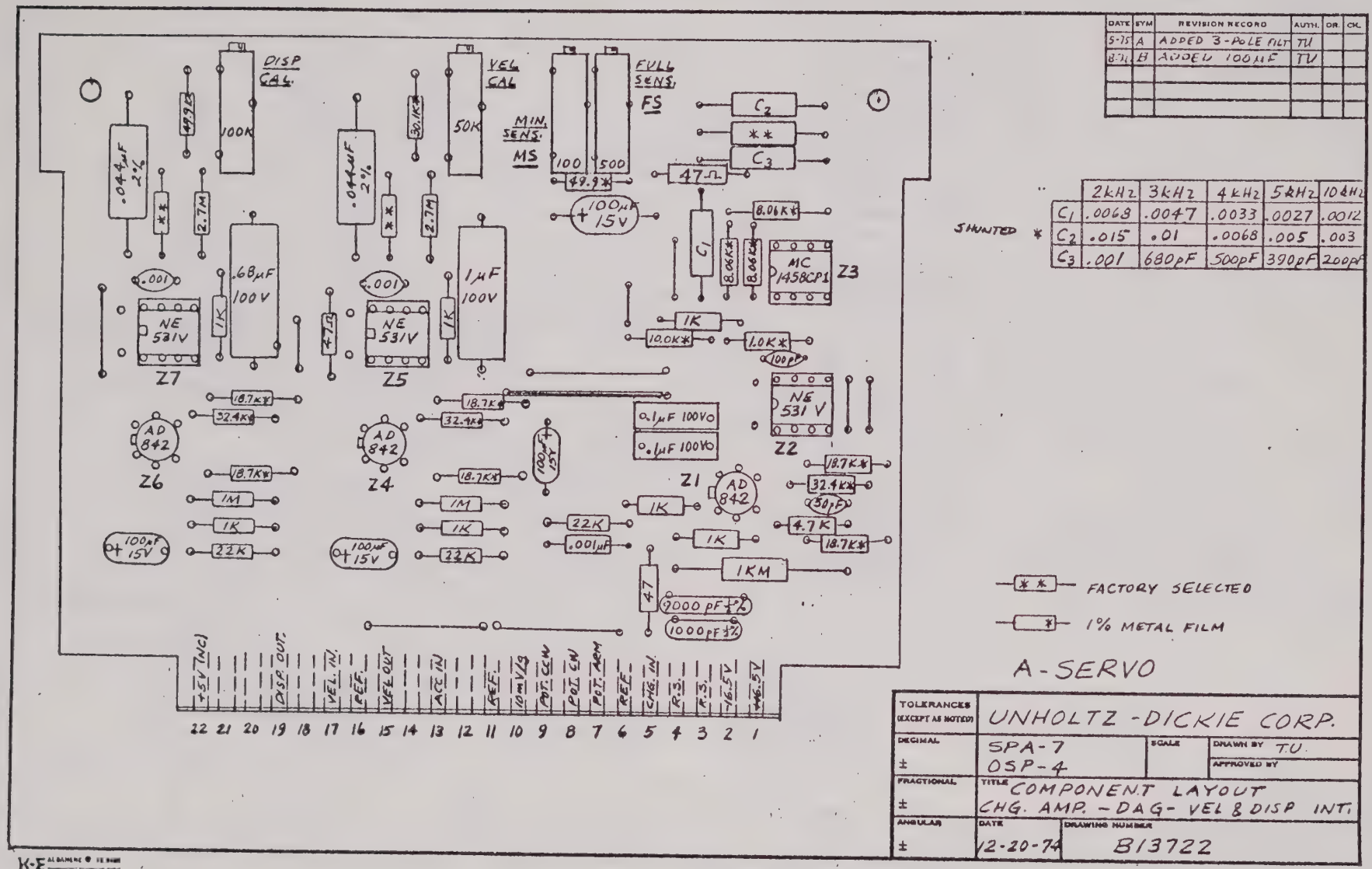
* 1% METAL FILM
** SHUNTED

| | 2kHz | 3kHz | 4kHz | 5kHz | 10kHz |
|---|---|---|---|---|---|
| $C_1$ | .0068 | .0047 | .0033 | .0027 | .0012 |
| $C_2$ | .015 | .01 | .0068 | .005 | .003 |
| $C_3$ | .001 | .5 | 500pF | 390pF | 200pF |

| IC | TYPE | PIN +16.5V | PIN -16.5V |
|---|---|---|---|
| Z1,5,7 | NE531V | 7 | 4 |
| Z3 | MC1458CP1 | 8 | 4 |
| | | | |

| | |
|---|---|
| TOLERANCES EXCEPT AS NOTED | UNHOLTZ-DICKIE CORP. |
| DECIMAL ± | MOD. SPA-7 MOD. OSP-4 |
| FRACTIONAL ± | TITLE CIRCUIT SCHEMATIC CHG. AMP.-DAG VT. CARD |
| ANGULAR | DATE DRAWING NUMBER |

A-SERVO




| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 5-75 | A | ADDED 3-POLE FILT | TU | | |
| 8-74 | B | ADDED 100µF | TU | | |

| | 2kHz | 3kHz | 4kHz | 5kHz | 10kHz |
|---|---|---|---|---|---|
| SHUNTED * $C_1$ | .0068 | .0047 | .0033 | .0027 | .0012 |
| $C_2$ | .015 | .01 | .0068 | .005 | .003 |
| $C_3$ | .001 | 680pF | 500pF | 390pF | 200pF |

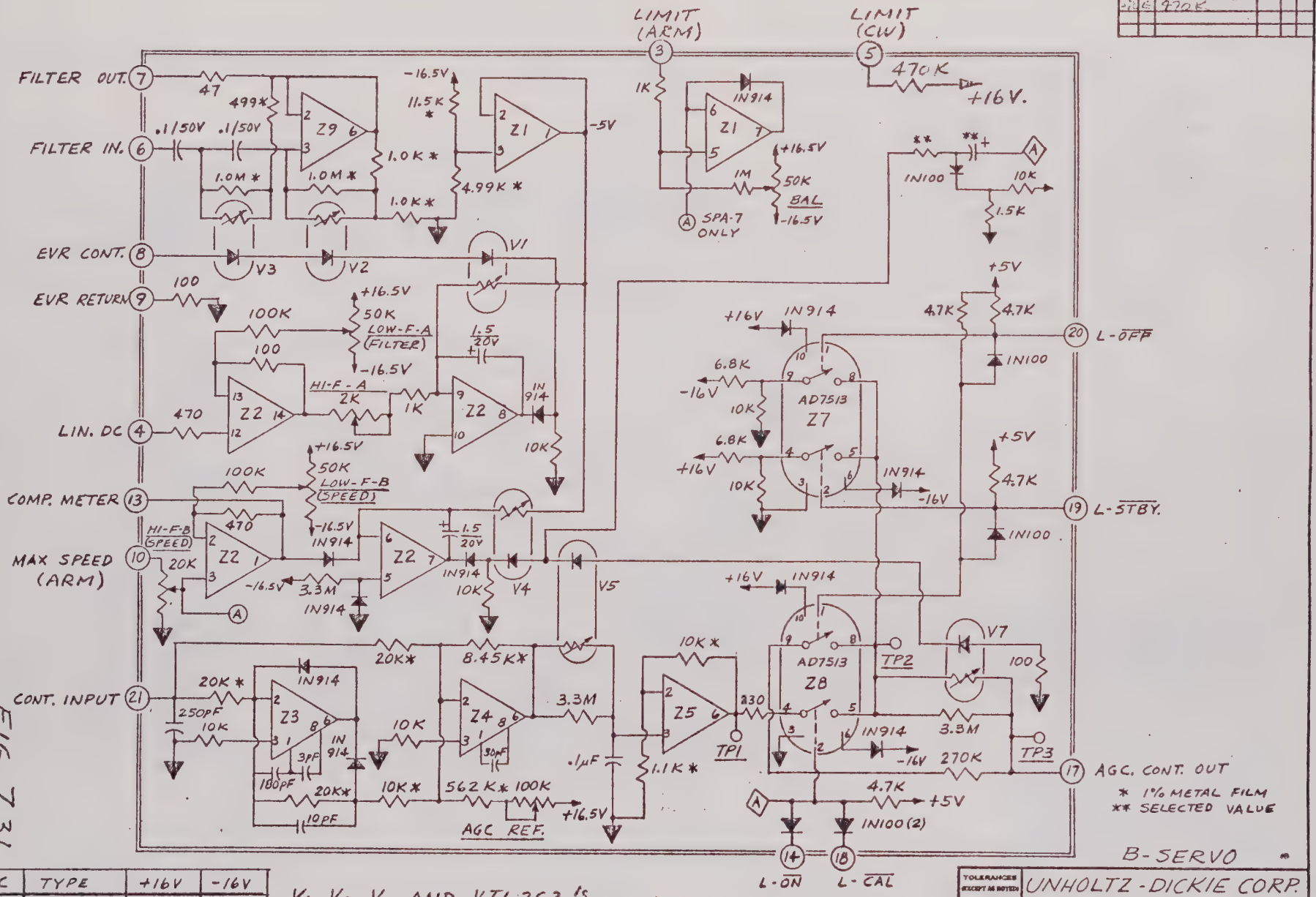
** FACTORY SELECTED

* 1% METAL FILM

A-SERVO

| | |
|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. |
| DECIMAL ± | SPA-7 OSP-4 |
| SCALE | |
| DRAWN BY T.U. | |
| APPROVED BY | |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT CHG. AMP. - DAG - VEL & DISP INT. |
| ANGULAR ± | DATE 12-20-74 |
| DRAWING NUMBER | B13722 |

K-E




| IC | TYPE | +16V | -16V |
|---|---|---|---|
| Z1 | MC1458CP1 | 8 | 4 |
| Z2 | MC3303P | 4 | 11 |
| Z3,Z4 | LM 30 | 7 | 4 |

V1, V2, V3 AND VTL2C2'S ON SW-1 THRU 4 MATCHED (7)
V4, V5, V7 MATCHED VTL2C1'S

| DATE | SYM | REVISION RECORD | AUTH. | OK. | OK. |
|---|---|---|---|---|---|
| 1/76 | D | DIODES Z9 SN108 | TU | | |
| 2/76 | E | 470K | | | |

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | MOD SPA-7 MOD. OSP-4 | SCALE — | DRAWN BY TU |
| FRACTIONAL ± | TITLE CIRCUIT SCHEMATIC AGC CONTRL CARD | | APPROVED BY |
| ANGULAR ± | SIZE | DRAWING NUMBER | |

B-SERVO

FIG 7.31

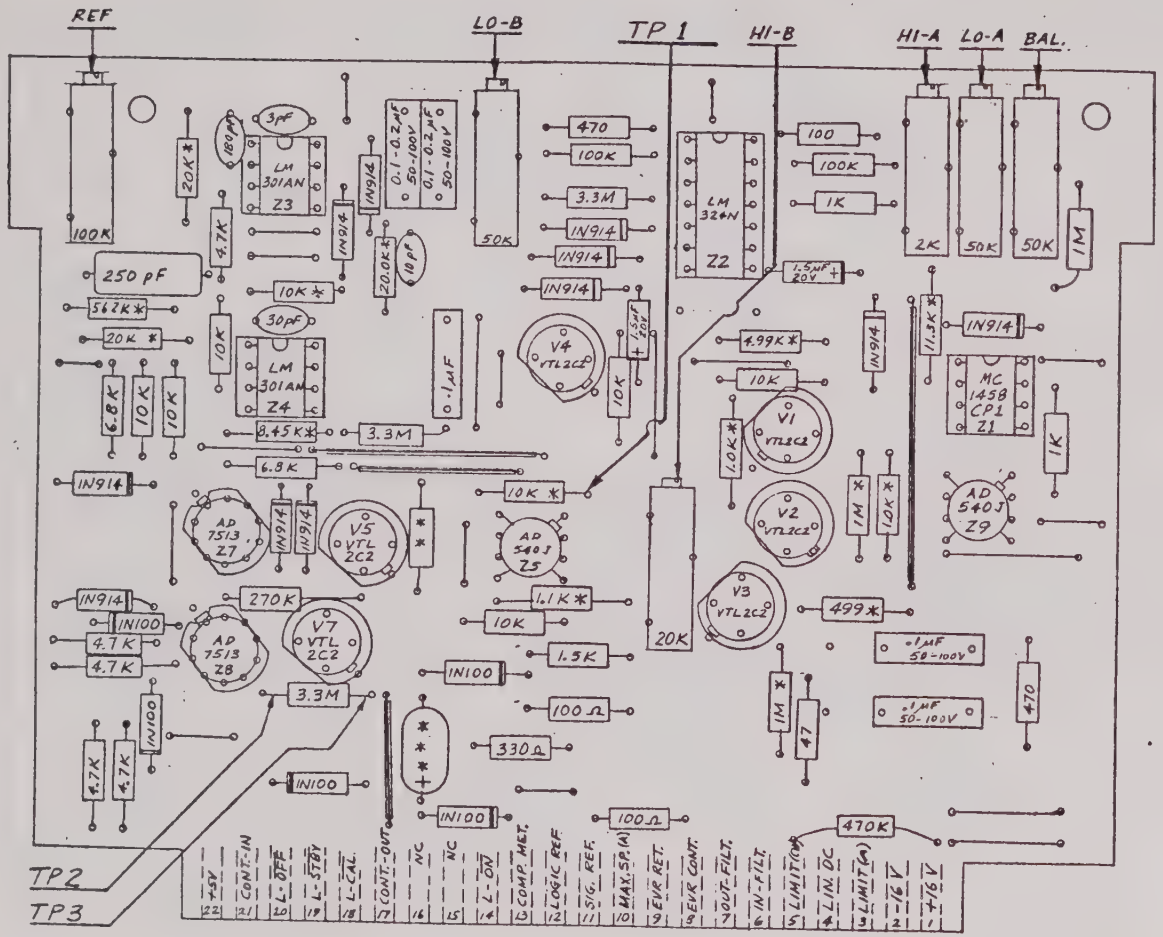

REF
LO-B
TP 1
HI-B
HI-A
LO-A
BAL.
100K
20K *
180pF
3pF
LM 301AN Z3
4.7K
IN914
0.1 - 0.2 μF 50-100V
0.1 - 0.2 μF 50-100V
20.0K *
10pF
50K
470
100K
3.3M
IN914
IN914
IN914
LM 324N Z2
100
100K
1K
2K
50K
50K
1M
250 pF
562K *
20K *
10K *
30pF
LM 301AN Z4
10K
0.1μF
V4 VTL2CP
1.5μF 20V
1.5μF 20V
4.99K *
10K
V1 VTL2C2
1.0K *
IN914
11.3K *
IN914
MC 1458 CP1 Z1
1K
6.8K
10K
10K
8.45K *
3.3M
6.8K
IN914
10K *
AD 7513 Z7
IN914
IN914
V5 VTL 2C2
AD 540J Z5
V2 VTL2C2
1M *
10K *
AD 540J Z9
IN914
270K
IN100
4.7K
4.7K
AD 7513 Z8
V7 VTL 2C2
1.1K *
10K
1.5K
V3 VTL2C2
20K
499 *
.1μF 50-100V
.1μF 50-100V
470
IN100
3.3M
100Ω
330Ω
1M *
47
4.7K
4.7K
IN100
IN100
IN100
100Ω
470K
TP2
TP3
+5V
CONT-IN
L-DIFF
L-STBY
L-CAL
CONT-OUT
NC
NC
L-ON
COMP. MET.
LOGIC REF.
SIG. REF.
MAX. SP. (N)
EVR RET.
EVR CONT.
OUT-FILT.
IN-FILT.
LIMIT (OUT)
LIN. DC
LIMIT (IN)
-16 V
+16 V
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
* 1% METAL FILM
** SELECTED (15K - 47K)
*** SELECTED (10 - 100 μF)
B-SERVO
UNHOLTZ - DICKIE CORP
SPA-7
OSP-4
COMPONENT LAYOUT
AGC CONTROL CARD
11-5-74
D 13714

FIG 7.32

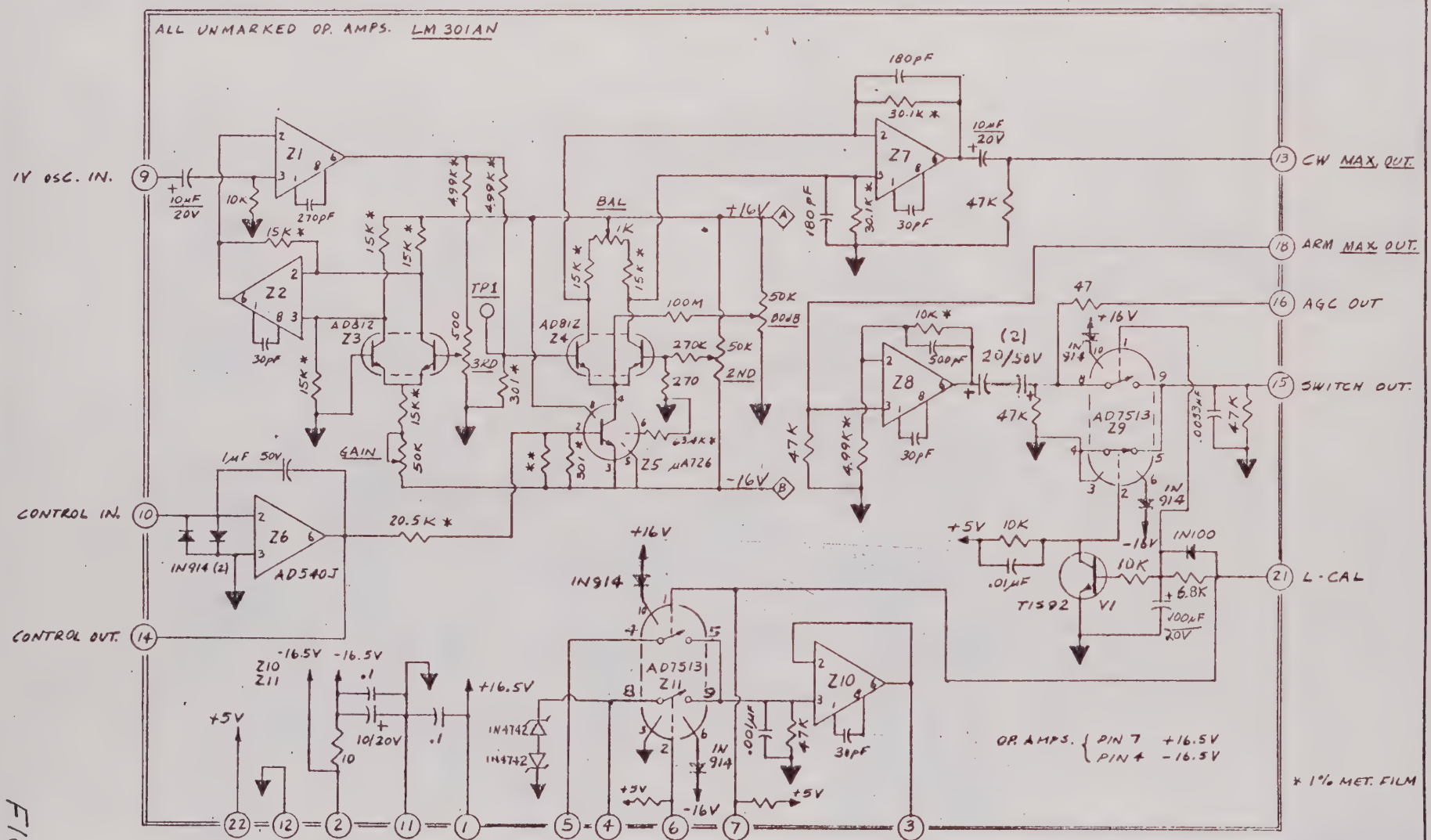
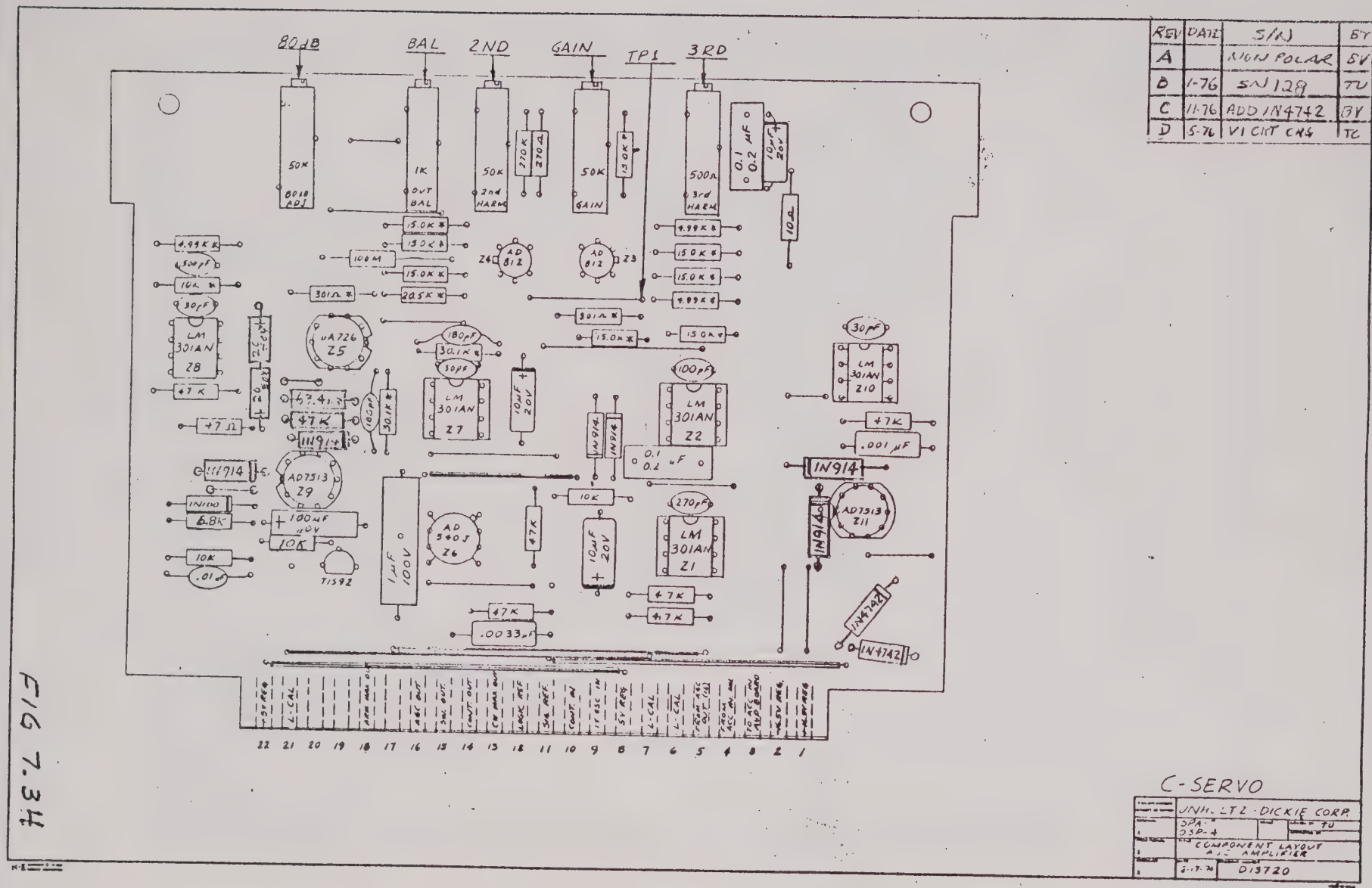

ALL UNMARKED OP. AMPS. LM 301AN
1V OSC. IN.
CONTROL IN.
CONTROL OUT.
CW MAX. OUT.
ARM MAX. OUT.
AGC OUT
SWITCH OUT.
L-CAL
+5V REG
LOGIC REF.
-16.5V REG
SIGNAL REF
+16.5V REG
FROM 16
FROM ACC IN SWITCH
L-CAL
L-CAL
TO ACC IN AVD CARD
AD812
AD7513
AD540J
IN914
IN4742
TIS92
IN100
GAIN
BAL
TP1
2ND
OP. AMPS. PIN 7 +16.5V
PIN 4 -16.5V
* 1% MET. FILM
C-SERVO
UNHOLTZ-DICKIE CORP.
MOD. SPA-7
MOD. OSP-4
CIRCUIT SCHEMATIC
AGC AMPLIFIE CARD

FIG 7.33




| REV | DATE | S/N | BY |
|---|---|---|---|
| A | | NON POLAR | SV |
| B | 1-76 | SN 128 | TU |
| C | 11-76 | ADD IN4742 | BY |
| D | 5-76 | VI CKT CHG | TC |

C-SERVO

UNIV. LTZ · DICKIE CORP.

DPA-4 DSP-4 — TU

COMPONENT LAYOUT A/C AMPLIFIER

2-17-76 — D13720

FIG 7.3H

| DATE | BY | REVISION RECORD | AUTH | CHK | APP |
|---|---|---|---|---|---|
| 10/1 | A | 1.0 K → 975 | TU | | |
| | B | CHANGE 100K | TU | | |
| 9/1 | C | SHIFT Z3 | TU | | |
| 9/11 | D | ADD OUTPUT DIODE | TU | | |

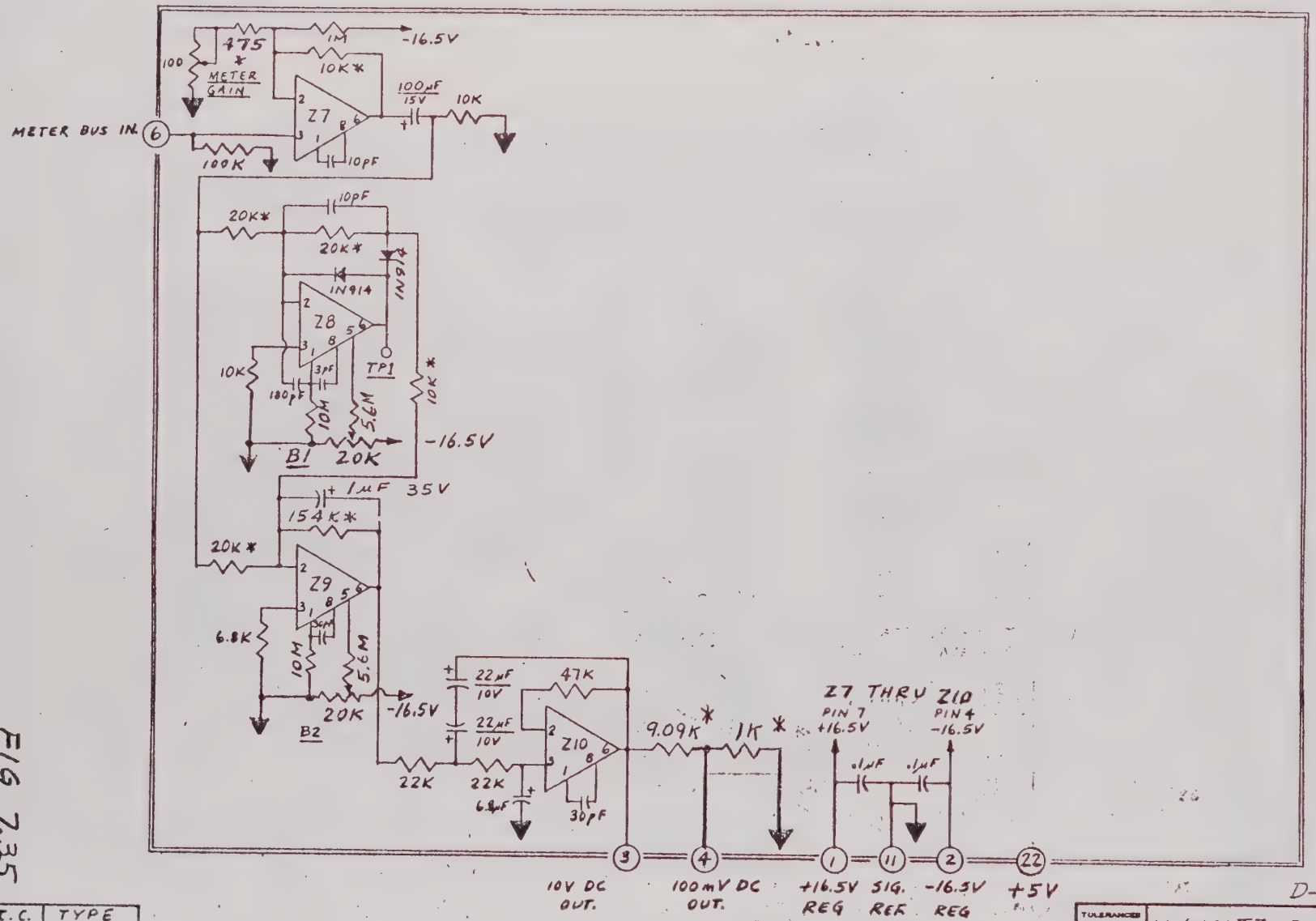



FIG 7.35

* 1% METAL FILM

| I.C. | TYPE |
|---|---|
| Z1 | LM324N |
| Z2 | LM339N |
| Z3,Z4 | 7404N |
| Z5,Z6 | 7400N |

D-SERVO

UNHOLTZ-DICKIE CORP.

MOD. 05P-4

DRAWN BY TU

TITLE CIRCUIT SCHEMATIC METER CONT. CARD

| | | |
|---|---|---|
| 10-8 | A | 1.05K ⇒ 475 TU |
| 5-76 | B | SN 123 TU |
| 7-81 | C | CHG OUTPUT DIVIDER R |
| | | |
| | | |

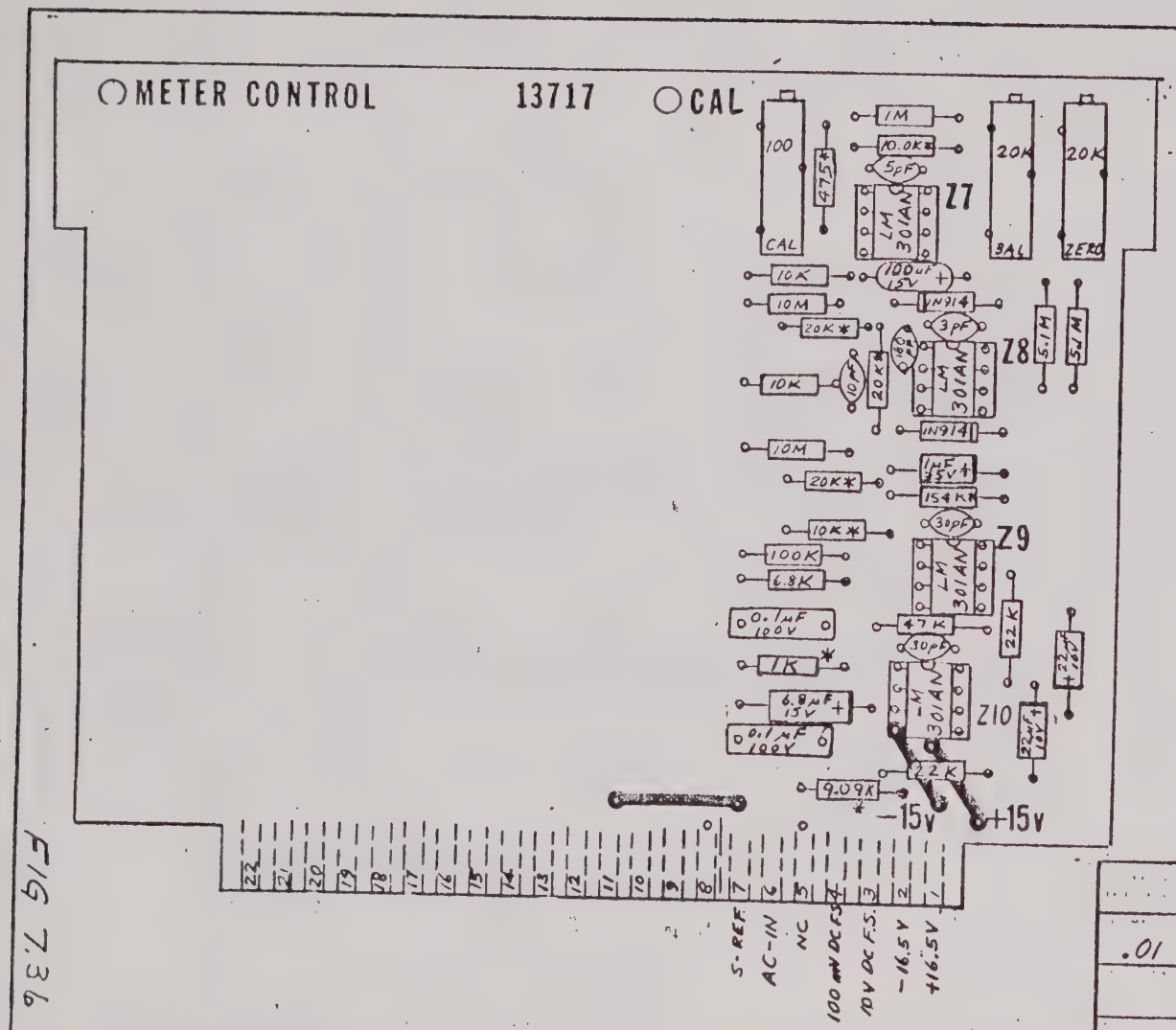
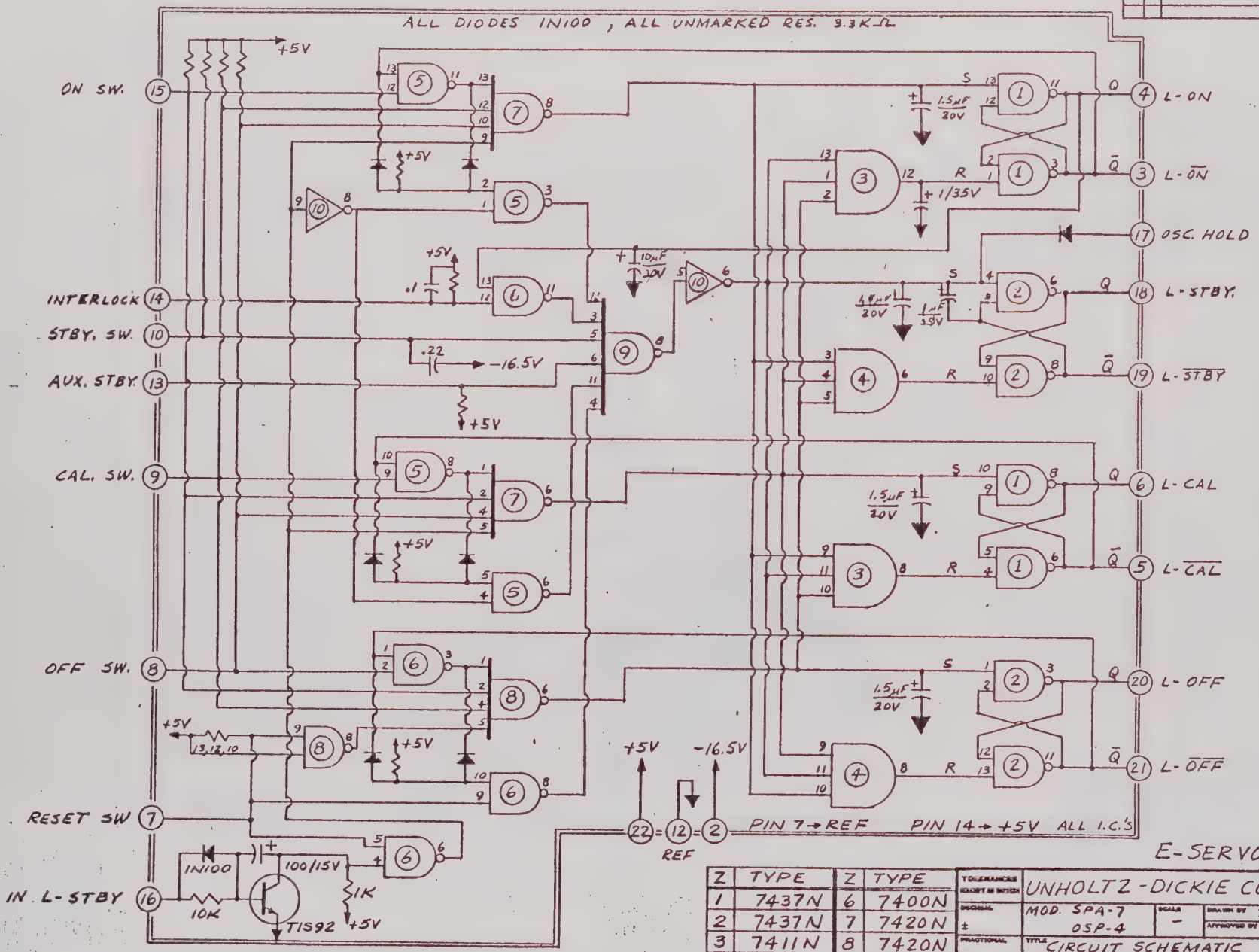



FIG 7.36

D-SERVO
** SELECTED AT CHECKOUT
* - DENOTES 1% METAL FILM

| | |
|---|---|
| | UNHOLTZ-DICKIE CORP |
| .01 | MOD. OSP-4 TU |
| | COMPONENT LAYOUT METER AMP. - RANGE CONTROL |
| | 12-5-74 B13718 |




| Z | TYPE | Z | TYPE |
|---|---|---|---|
| 1 | 7437N | 6 | 7400N |
| 2 | 7437N | 7 | 7420N |
| 3 | 7411N | 8 | 7420N |
| 4 | 7411N | 9 | 7430N |

UNHOLTZ-DICKIE CORP.

MOD. SPA-7
OSP-4

CIRCUIT SCHEMATIC
MODE CONTRO CARD

FIG 7.37

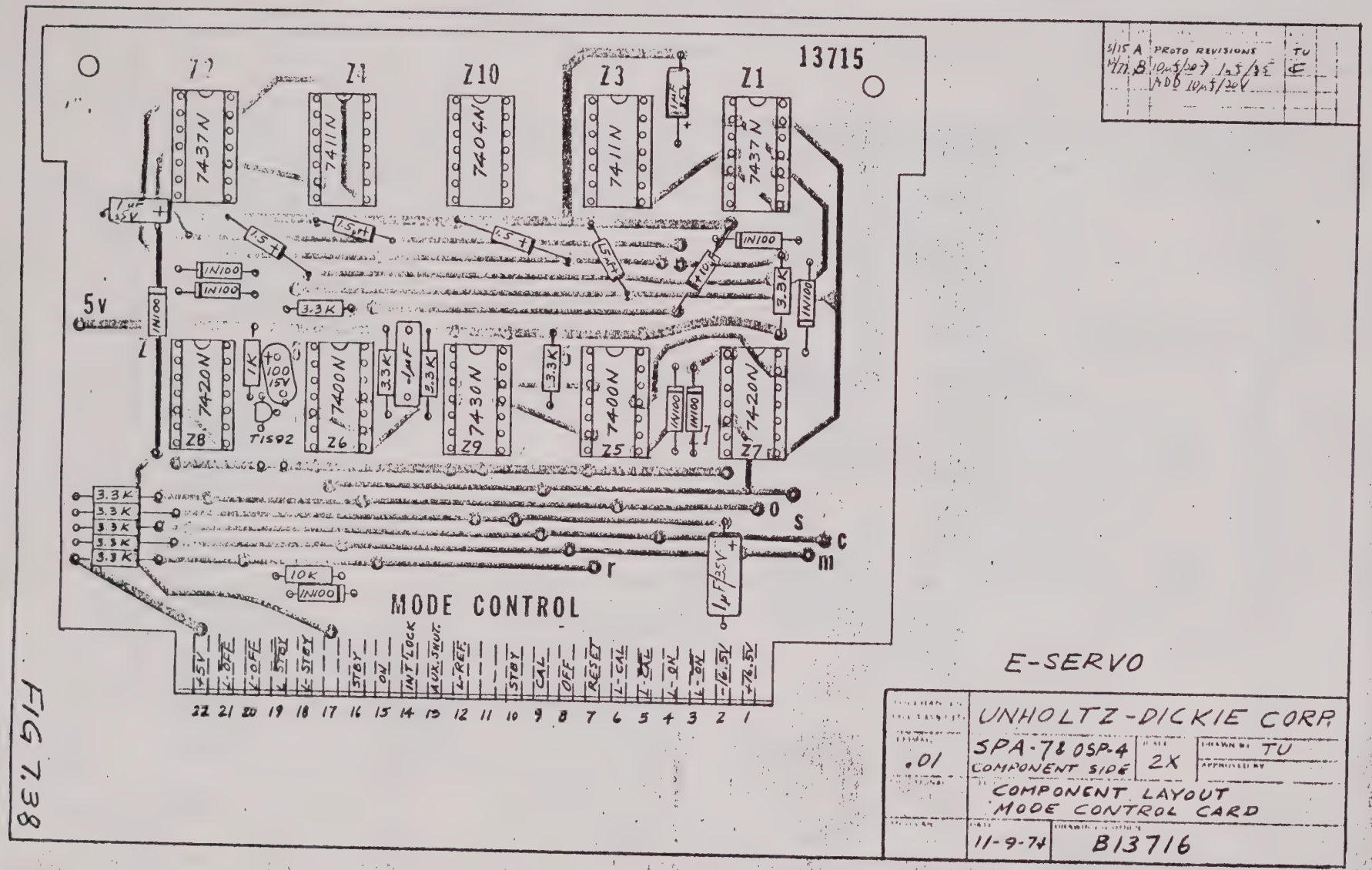
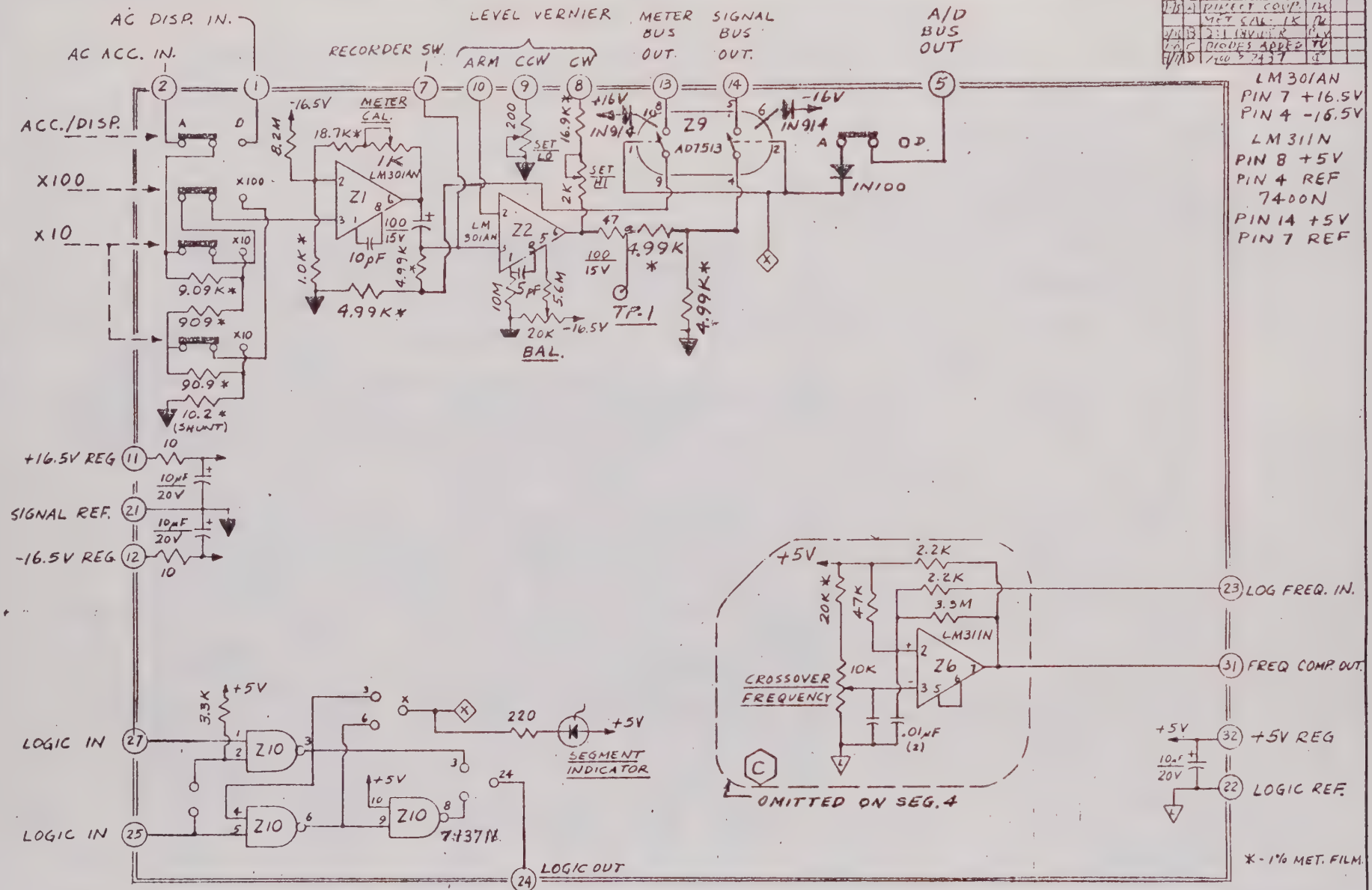



FIG 7.38

| REV | PROTO REVISIONS | |
|---|---|---|
| 5/15 A | | TU |
| 6/17 B | 10μF/20V 1.5/35 ADD 10μF/20V | E |

E-SERVO

| | | | |
|---|---|---|---|
| .01 | UNHOLTZ-DICKIE CORP. | | |
| | SPA-7 & OSP-4 COMPONENT SIDE | 2X | DRAWN BY TU |
| | COMPONENT LAYOUT MODE CONTROL CARD | | |
| | 11-9-74 | B13716 | |




| JUMPERS Z10 | SEGMENTS OSP-4 | |
|---|---|---|
| 6-X | 1 | |
| 3-X, 2-5, 8-24 | 2, 3 | |
| 3-X, 2-24 | 4 | |

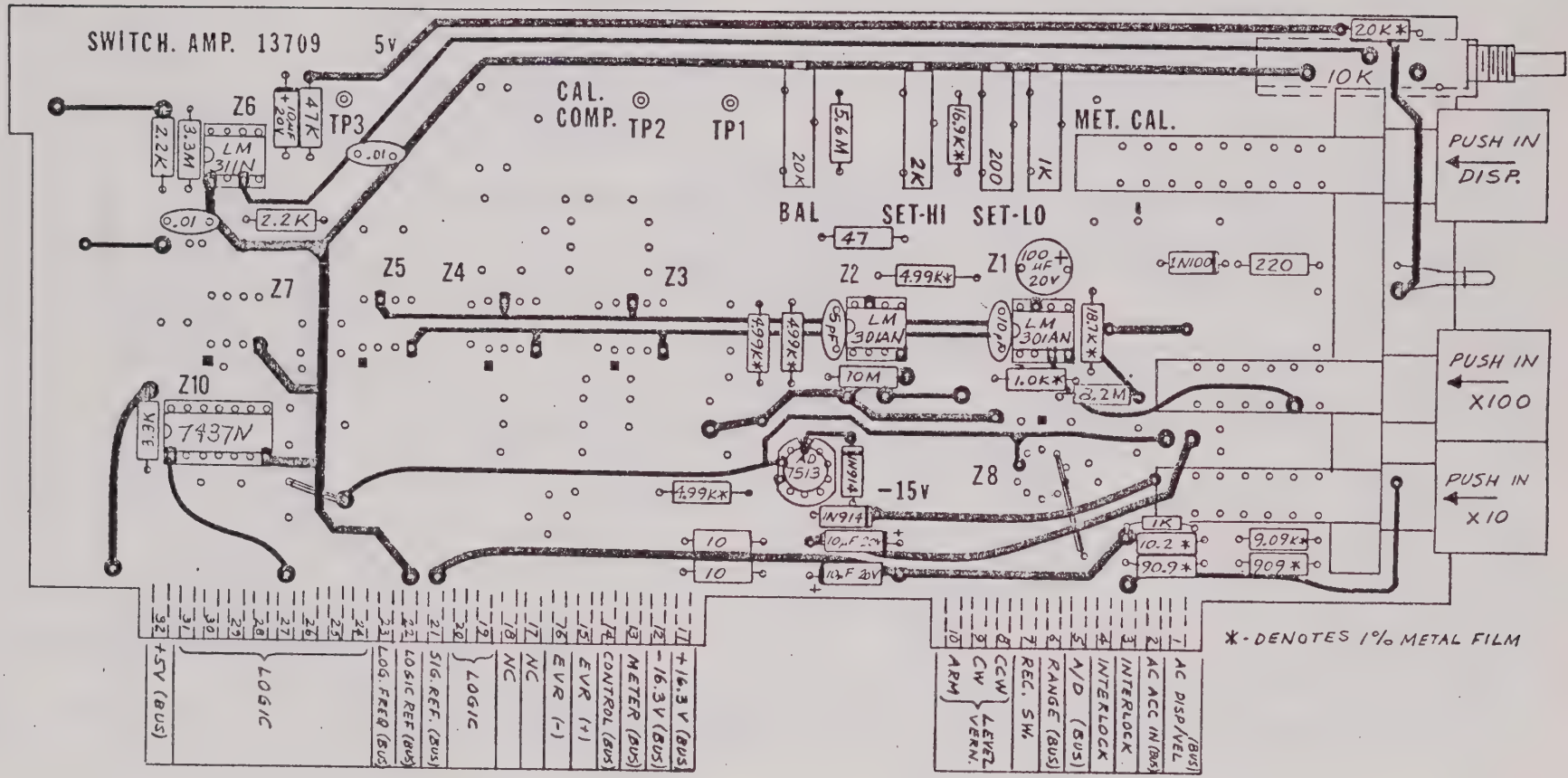
SW-SERVO

UNHOLTZ-DICKIE CORP.

MOD OSP-4

CIRCUIT SCHEMATIC SWITCHING AMPLIFIER CARDS

FIG 7.39



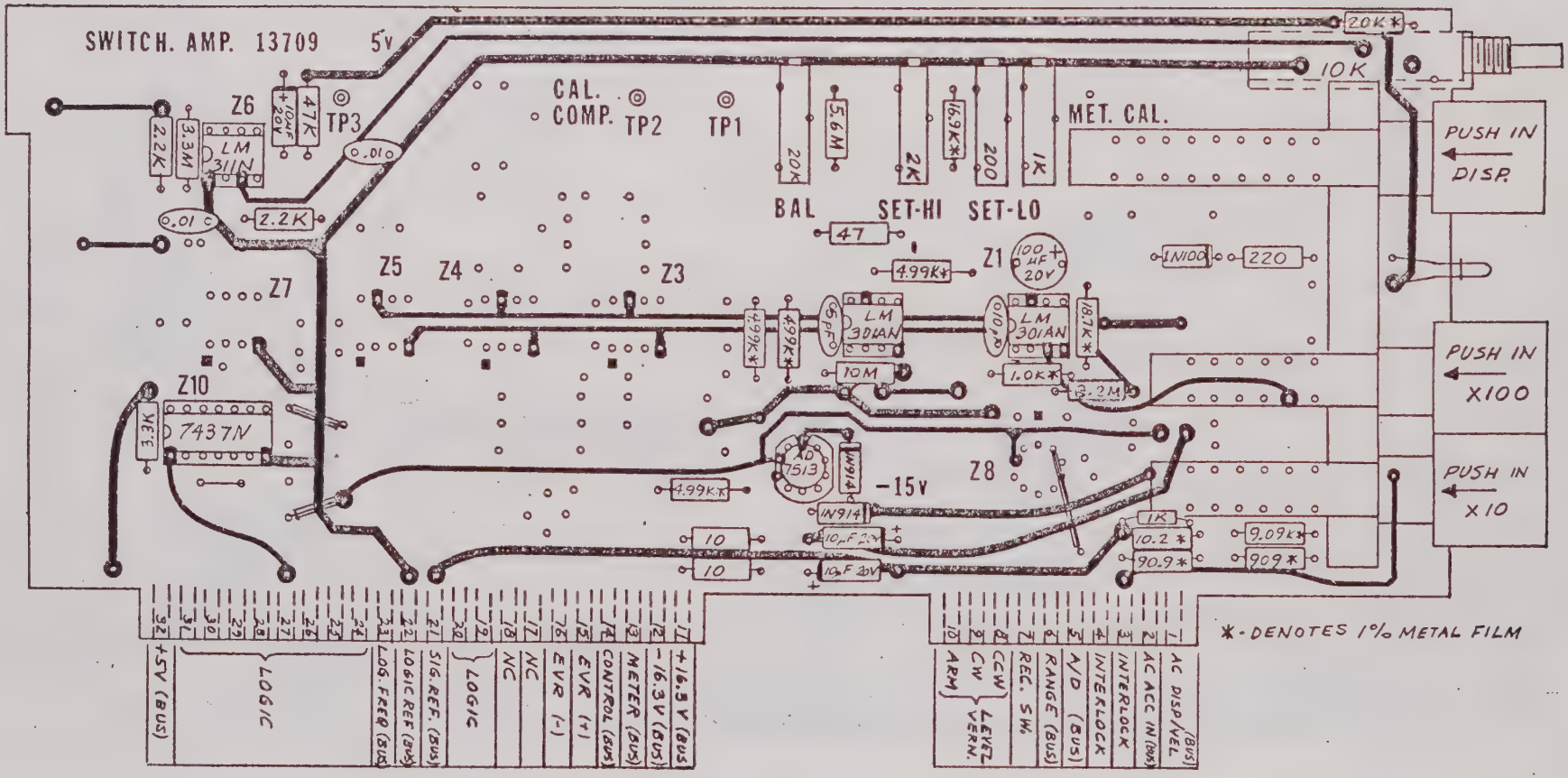

*-DENOTES 1% METAL FILM

SEGMENT 1 OSP-4

| | | | |
|---|---|---|---|
| TOLERANCES UNLESS NOTED | U-D CORP | | |
| DECIMAL ± | | SCALE | DRAWN BY / APPROVED BY |
| FRACTIONAL ± | TITLE: SWITCH CARD COMPONENT LAYOUT | | |
| ANGULAR ± | DATE: 1-31-76 | DRAWING NUMBER: C13734 | |

SW-1 SERVO

Fig 7.40

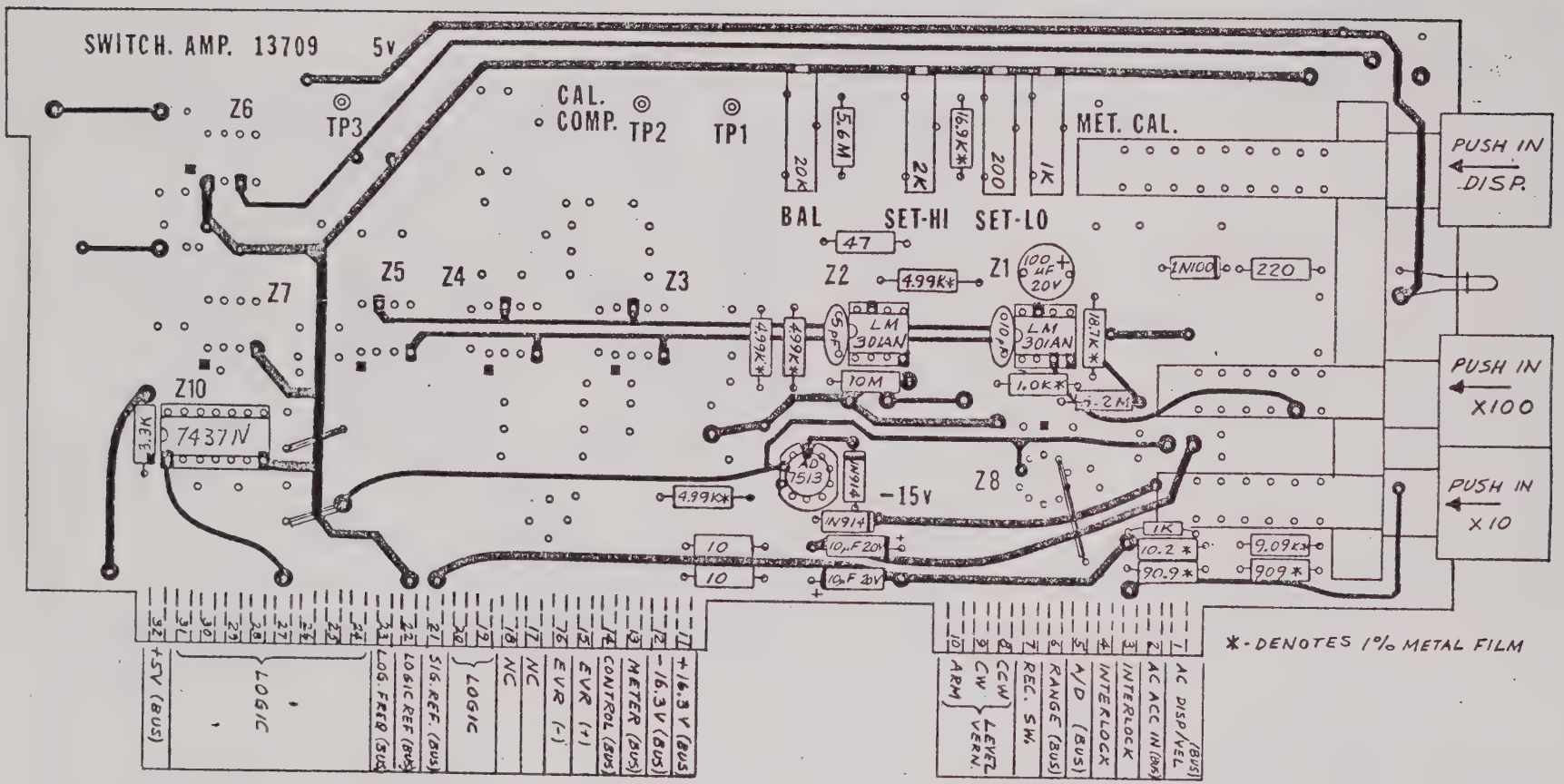



SEGMENT 2, 3 OSP-4

| | |
|---|---|
| TOLERANCES EXCEPT AS NOTED | U-D CORP |
| DECIMAL ± | SCALE |
| FRACTIONAL ± | TITLE SWITCH CARD COMPONENT LAYOUT |
| ANGULAR ± | DATE 1-31-76 DRAWING NUMBER C13 2 |

SW-2,3 SERVO

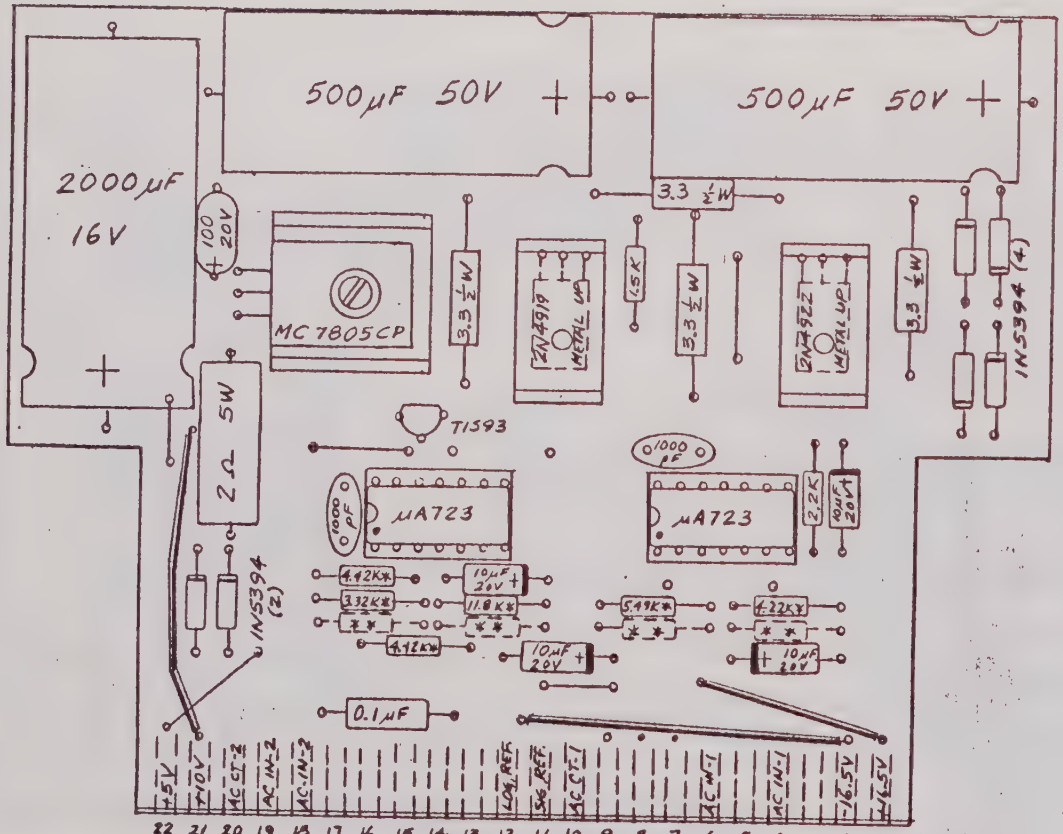
Fig 7.41




SEGMENT 4 OSP-4

| | | | |
|---|---|---|---|
| TOLERANCES EXCEPT AS NOTED | U-D CORP | | |
| DECIMAL ± | | SCALE | DRAWN BY / APPROVED BY |
| FRACTIONAL ± | TITLE SWITCH CARD COMPONENT LAYOUT | | |
| ANGULAR ± | DATE 1-31-76 | DRAWING NUMBER C13733 | |

SW-4 SERVO




| DATE | SYM | REVISION RECORD | AUTH. | OR. | CK. |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

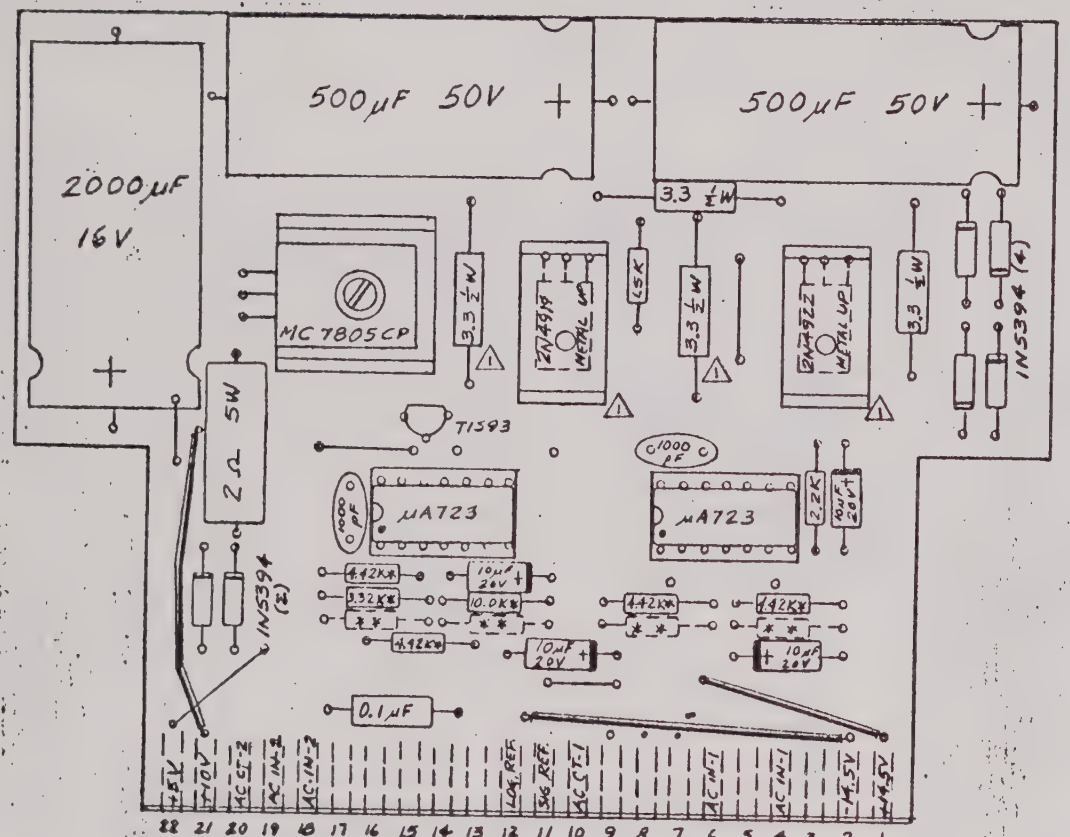
** - FACTORY SELECT
* - DENOTES 1% METAL FILM

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | SPA-7<br>OSP-4 | SCALE 2X | DRAWN BY TU<br>APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT POWER SUPPLY CARD | | |
| ANGULAR ± | DATE 1-5-74 | DRAWING NUMBER B13724 | |

FIG 7.43

PS-SERVO

K-E




| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 7/74 | A | NOTE 1 | | | |

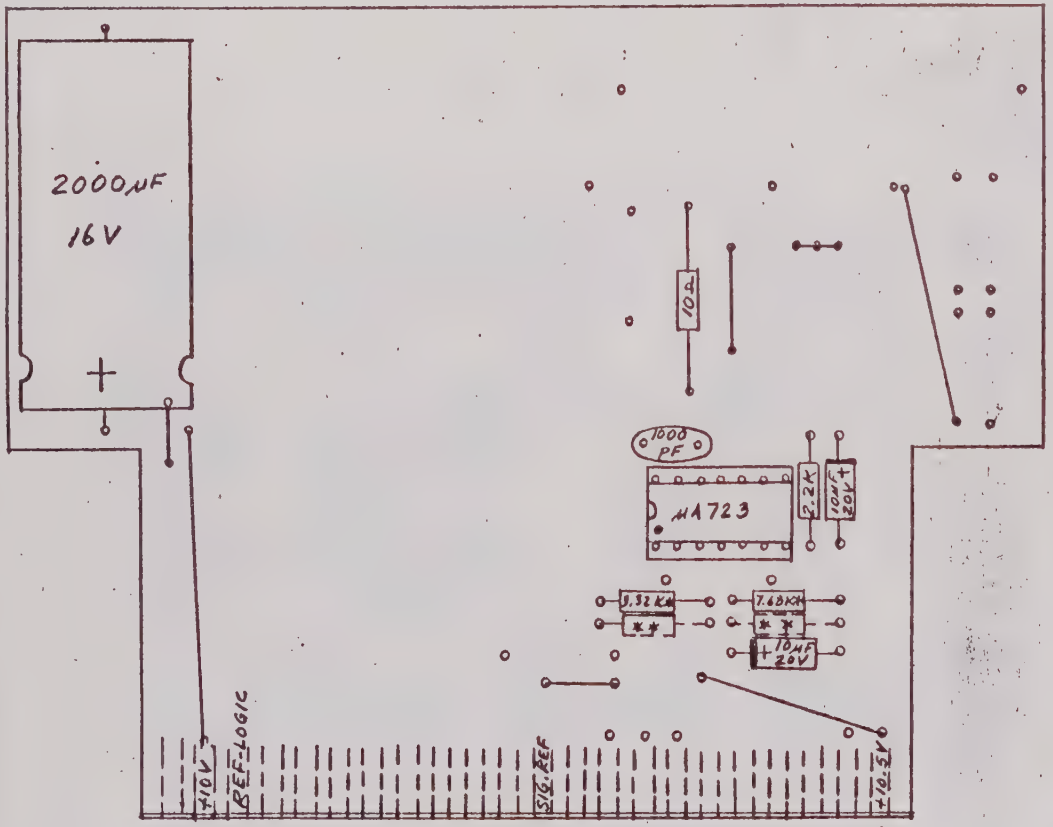
⚠1 OPTION RD (RES. DWELL & COUNTER): 3.3Ω BECOMES 2.2Ω; HEAT SINKS' SIZE INCREASED.

** - FACTORY SELECT
* - DENOTES 1% METAL FILM

| | |
|---|---|
| TOLERANCES EXCEPT AS NOTED | UNHOLTZ-DICKIE CORP. |
| DECIMAL ± | SPA-7 OSP-4 |
| SCALE | 2X |
| DRAWN BY | TU |
| APPROVED BY | |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT POWER SUPPLY CARD |
| ANGULAR ± | DATE 1-5-74 |
| DRAWING NUMBER | B13821 |

PS-OSC-1

FIG 7.44




| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| | | | | | |

** FACTORY SELECT

* DENOTES 1% METAL FILM

| | | | |
|---|---|---|---|
| TOLERANCES EXCEPT AS NOTED | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | OSP-4 | SCALE | DRAWN BY TU |
| | | | APPROVED BY |
| FRACTIONAL ± | TITLE COMPONENT LAYOUT POWER SUPPLY CARD | | |
| ANGULAR ± | DATE 7-12-75 | DRAWING NUMBER B13822 | |

PS-OSC-2

FIG 7.45

K·E ALBANENE ® 10 SAME

# 8. SPECIFICATIONS

ALL SPECIFICATIONS APPLY AFTER 10 MINUTES WARMUP

1. FREQUENCY

   1.1 Range: 5-5000 Hz
   1.2 Stability: ±1% or 0.5 Hz, whichever is larger for 8 hours in MANUAL or RESET mode.
   1.3 Display: 4-digit counter with .27 in. high LED display. Resolution is 1.0 Hz at a 10 sample/second rate
   1.4 Display Accuracy: ±resolution ±power frequency accuracy

2. AC OUTPUTS

   2.1 Oscillator Output: 1 V rms, ±.5 dB, 5-5000 Hz; Distortion less than 0.3% 20-3000 Hz, less than 0.5% 5-5000 Hz; Output impedance - 100 ohms
   2.2 Compressor Output: 10 V rms max; Distortion less than 0.3% 20-3000 Hz, less than 0.5% 5-5000 Hz, Compressor OFF mode and ON mode, 0-20 dB compression, 10-3000 dB/sec; Output impedance - 50 ohm
   2.3 Charge Output: 10 mV/g, 10 V p max; output impedance - 50 ohm

3. DC OUTPUTS

   3.1 DC ∝ LOG FREQ: 0 - 1.2 V (.4 V/decade); Linearity and stability 0.3 Hz or ±3%
   3.2 DC ∝ FREQ 0 - 10 V (2 mV/Hz); Stability ±2% or 1 Hz.
   3.3 DC ∝ LOG AMPL (OPTIONAL): -3V to 0V (50 mV/dB); Accuracy ±.2 dB 0 to -40 dB, ±.5dB -40 to -60 dB

4. COMPRESSOR (AGC) AMPLIFIER

   4.1 Dynamic Gain Range: greater than 80 dB with compression indicated by front panel meter 0-30 dB
   4.2 Compression Characteristic: Linear from 0 to 70 dB
   4.3 Correction Accuracy: Essentially zero static error 70 dB gain change results in less than 0.1 dB change in test level.
   4.4 Speed: Automatically controlled as a continuous function of frequency from 10 dB/sec at 5 Hz to a switch-selected upper limit of 100, 300, 1000, or 3000 dB/sec at 5 kHz.
   4.5 Turn On: Less than 5 sec from > 80 dB compression to full test level at 5 Hz.
   4.6 Modes (Indicator lights for all modes)
   ON: Compressor active for closed-loop operation. Compressor speed automatically controlled.
   STBY: Compressor output smoothly reduced to more than 80 dB below full output
   LEVEL CAL: Allows closed-loop operation with zero compressor output. Used for occasional calibration and check of operation.
   OFF: Compressor inactive. Compression held at 0 dB.

5. SWEEP OSCILLATOR

   5.1 Sweep Mode - logarithmic - continuous over 3 decades
   5.2 Sweep Time - 1 to 99.9 minutes in 0.1 minute increments. Thumbwheel setting with digital display. Setting is independent of sweep frequency limits. Maximum sweep rate is 3 decades/minute.
   5.3 Sweep Reversal Limits - Each settable with 10 turn controls. Low Limit: 5 to 5000 Hz. High Limit: Low limit to 5,000 Hz
   5.4 Modes (all are pushbutton-actuated)
   SWEEP: Indicates frequency sweep from MANUAL RESET or HOLD mode. Indicator lights for direction.
   REVERSE: Causes reversal of sweep direction.
   HOLD: Stops frequency sweep. Indicator light.
   RESET UP/DOWN: Holds frequency at value determined by upper/lower limit control. Color-indicating pushbuttons.
   MANUAL: Holds frequency at value determined by COARSE and FINE frequency controls. Color-indicating pushbutton.
   5.5 External Sweep - available at rear connector
   5.6 Oscilloscope sweep (Option): Oscilloscope sweep synchronized to 3 periods of oscillator output

6. PROGRAMMER

   6.1 Test Programs: As many as four segments with displacement and acceleration in any combination or sequence. Displacement selection shown by color-indicative pushbutton. Active segment shown by LED indicator.
   6.2 Crossover Frequencies: Independently adjustable 5-5000 Hz.
   6.3 Level Verniers: Ten-turn precision potentiometer with locking dial providing 1% settability of level without presetting operation. Displacement: .001 to .011 in p-p; Acceleration: .1 to 1.1 g peak.
   6.4 Level Multipliers: X10 and X100 with color-indicating pushbuttons usable in any combination providing the following full-scale ranges: Displacement: .01, .1, 1, 10 in p-p. Acceleration: .1, 10, 100, 1000 g p.
   6.5 Vibration Meter: Taut-band movement; 3 in. mirror scale; monitors vibration level of active program segment.
   Accuracy:
   Disp: ±2% of reading ±1% of full scale, 5 to 1000 Hz: (.01 in. range) 50 to 1000 Hz
   Accel: ±1% of reading ±1% of full scale, 5 to 5000 Hz.

7. ACCELERATION SIGNAL

   7.1 Normalized 10 mV/g input - input impedance 47 kilohm
   7.2 Charge Input: Adjustable for sensitivities 1-100 pC/g.

8. INTERLOCKS

   8.1 With compressor ON, MAX. OUTPUT turned CW, STBY mode is established if LEVEL CAL, OFF, A/D, X10, X100, oscillator RESET, or MAN. pushbutton is actuated.
   8.2 With compressor in LEVEL CAL (or OFF) mode and MAX OUTPUT is CW, STBY mode is established if ON, OFF (or LEVEL CAL), oscillator RESET, or MAN pushbutton is actuated.
   8.3 If SERVO goes to STBY for any reason and oscillator is in SWEEP mode, the oscillator automatically goes to HOLD mode.

9. REMOTE CONTROL (OPTIONAL) Separate unit has push-buttons to provide closed-loop operating functions once programmer controls are set. Push-buttons provided: Compressor ON, LEVEL CAL, STBY, SWEEP, REVERSE, HOLD, RESET UP, RESET DOWN. Indicator lights or color indicating buttons are included to indicate active control functions.

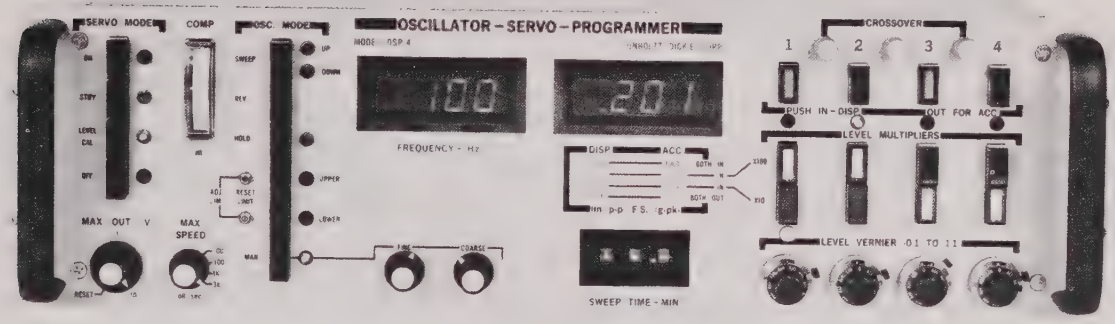
10. POWER: 105-125/210-250 VAC 50-60 Hz 40 VA

11. SIZE: 5.25" HIGH x 19" WIDE x 18" DEEP plus cables

UNHOLTZ-DICKIE CORPORATION

VIBRATION TEST EQUIPMENT

# Model OSP-4 OSCILLATOR-SERVO-PROGRAMMER




## Complete sine control instrument including charge amplifier and meter

- Short 10 minute warmup produces specified operation with stable log DC outputs.
- Servo has **zero** static error and more than 80 dB dynamic range.
- Amplifier drive signal has extremely low distortion, for **both** closed-loop and open-loop operation.
- Human-engineered front panel with LED indicators and color-coded push-button operation provides ease of operation and visual monitoring.
- 4-segment programming with any sequence of acceleration and displacement is possible.
- Smooth crossovers or step-changes in vibration level may be programmed between segments.
- No "off the air" presetting operation necessary with calibrated, locking 10-turn level-setting controls.
- Fully interlocked push-button controls prevent operator errors and specimen damage.
- Minimum startup delay for "on the air" operation from full compression at low frequencies.
- Compressor speed is automatically programmed as a function of frequency.
- When a standby command is received, the output signal compresses at maximum possible speed without generating high frequency transients.
- Digital frequency display with 1 Hz resolution.
- Digital vibration meter.
- Digitally-generated sine wave.
- Oscillator sweeps over any part of the 3-decade frequency range.
- Digital selection of sweep time, independent of selected frequency sweep limits.
- Integral charge amplifier accepts accelerometer signals directly with sensitivities from 1 to 100 pC/g.
- Sweep signal option is available to allow scope display of three fundamental periods of any vibration signal regardless of frequency.
- Remote control option allows the test to be started and stopped at the shaker.
- X-Y plotting with optional log DC output for amplitude.
- Low profile chassis - only 5.25 inches high.
- Solid state, plug-in card design, employing many integrated circuits and CMOS switches.

# Application and Description

The Model OSP-4 is systems engineered to provide the generation, control, and measurement of a complete sinusoidal vibration test. It is compatible with all commercially available shaker-power amplifier combinations, and only an accelerometer is required to perform a complete vibration test. A typical test setup is shown in FIG. 1, in which optional instrumentation is shaded.

The programmer section provides for as many as four segment programs. Push-button controls allow range selection and selection of displacement or acceleration for each segment. The crossover frequencies are independently controlled. Tests in MIL-STD-810 and MIL-STD-331 are easily programmed, and segments of constant acceleration and constant displacement can be established in any sequence, giving complete flexibility of setup and control.

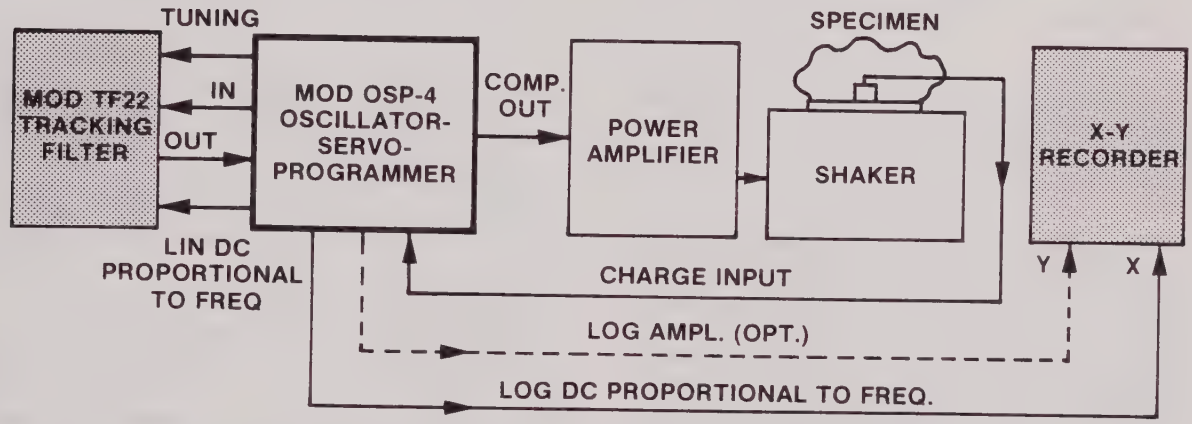



**FIG. 1 TYPICAL TEST SYSTEM BLOCK DIAGRAM**

The OSP-4 offers simplicity, reliability, ease of test setup and operation, and new performance features not found in other combination test instruments.

The oscillator section digitally generates a constant amplitude, extremely low distortion, log-sweep sine wave. It contains most of the features of the U-D Model OSC-1 Sweep Sine Generator.

The servo section provides a compressor or AGC circuit of improved design which provides zero static compression error instead of the heretofore typical 1 dB error for 60 dB gain variation. In addition, the turn-on time at low frequencies has been drastically reduced. Furthermore, the servo-controlled compressor output voltage contains very little harmonic content (typically 0.2%), and the distortion does not increase with compressor speed.

The zero static compression error feature and the precision ten-turn level vernier allow the test levels to be set up without resorting to the usual closed loop "off the air" presetting procedure. The level vernier settings also do not require readjustment during the actual test.

The integral charge converter and DIAL-A-GAIN sensitivity normalization allows the output from the control accelerometer to be fed directly to the OSP-4. Any sensitivity from 1 to 100 pC/g may be accommodated. Low-noise design identical to the U-D Model D22 Series instrumentation is utilized. This signal conditioning section may be bypassed if other instrumentation providing 10 mV/g control signals is utilized.

The Model OSP-4 is fully compatible with other accessories such as the U-D Models TF-22, MAC-8, and AM-123. A brief description of the operational controls and features follows.

## Operational Controls and Features

The controls and indicators for each section described above are grouped together for pleasing appearance and functional simplicity.

## Servo Mode

Four momentary-contact pushbuttons control the servo mode. One of the four color-coded LED indicators shows the active mode.

**ON** - The AGC amplifier of the servo controls the test to the programmed levels, and a continuously variable compressor speed as a function of frequency is provided.

**STBY** - The AGC amplifier is held at minimum gain so that the compressor (AGC) output voltage is over 80 dB below maximum output.

**LEVEL CAL.** - The AGC amplifier is operative and the compressor output is fed to the control input of the instrument for closed-loop operation without driving the power amplifier. This mode may be used occasionally for bench-checking the calibration of the LEVEL VERNIERS and RANGE SWITCHES. It is not required for a level presetting operation due to the precision features of the programmer.

**OFF** - The AGC amplifier is off and held at maximum output (0 dB compression). The output voltage is determined by the MAX. OUTPUT control for manual vibration level control.

## Compressor Speed

The compressor speed function is controlled by the setting of the MAX. SPEED switch. The speed varies continuously from 10 dB/sec at 5 Hz to the switch setting at 5 kHz. For most tests an upper limit of 1000 dB/sec is satisfactory.

## Oscillator Mode

Six momentary contact pushbutton switches control the oscillator mode. LED indicators show the active mode.

**SWEEP** - Depressing this pushbutton initiates a frequency sweep starting from the frequency determined by the HOLD, RESET, or MANUAL mode. The SWEEP TIME switch is active in this mode and determines the time between the UPPER and LOWER LIMITS, independent of the setting of the latter controls.

**REVERSE** - The direction of the frequency sweep is reversed by pushing this button.

**HOLD** - The frequency sweep is stopped by pushing this button. The HOLD mode is automatically actuated from the SWEEP mode when the servo goes to STBY for any reason.

**RESET, MANUAL** - Pushing either of the RESET buttons (UPPER or LOWER) or the MANUAL button sets the frequency at the value determined by the associated controls.

## Programmer Controls

Push in/out buttons provide selection of acceleration or displacement and the appropriate range for the desired test level for each of the four segments. An internal green indicator indicates the selection of displacement (IN) and the black color indicates acceleration (OUT). The two range pushbuttons provide four decade ranges with possible selection of no multiplier (X1) or either or both of the X10 or X100 multipliers. An internal white indicator shows active multiplier buttons.

The locking dial on the LEVEL VERNIERS allow the test levels to be set directly without presetting operations, with a settability of 1% or better. A lighted red LED indicates the segment in control.

## Metering

A digital vibration meter automatically indicates the amplitude of the segment in control, and compression is indicated by another meter. A four-digit counter indicates frequency with a large LED readout. Frequency is updated 10 times/second.

In the Compressor ON mode, the LEVEL CAL, OFF, A-D, X10, X100, oscillator RESET, and MAN switches are interlocked. Pushing any of these switches inadvertently could cause abrupt changes in the vibration level and possibly disastrous results. If any of these is switched, the compressor returns automatically to the STBY mode and the compression is increased at optimum speed to its maximum value. The oscillator is also automatically put in the HOLD mode from the SWEEP mode.

To establish automatic amplitude servo control, it is merely necessary to turn the MAX. OUTPUT full CW and depress the ON button until the ON indicator lights. If the OSP-4 is initially in the OFF or LEVEL cal modes, the servo will first go to the STBY mode and following full compression, automatically switch to the ON mode.

If manual vibration control in the servo OFF mode is desired, the MAX. OUTPUT must be turned CCW to the RESET position first. Otherwise, pushing the OFF button merely returns the servo automatically to STBY. This insures starting from zero vibration magnitude under manual control. The interlocks for the A-D, X10, and X100 switches are inactive in the OFF mode to allow switching of the vibration meter without causing shutdown. These same interlocks are inactive in the LEVEL CAL mode since the shaker is inoperative.

# Specifications

**All specifications apply after 10 minutes warmup**

## 1. Frequency

1.1 Range: 5-5000 Hz

1.2 Stability: ±1% or 0.5 Hz, whichever is larger for 8 hours in MANUAL or RESET mode.

1.3 Display: 4-digit counter with .56 in. high LED display. Resolution is 1.0 Hz at a 10 sample/second rate

1.4 Display Accuracy: ±resolution ±power frequency accuracy

## 2. AC Outputs

2.1 Oscillator Output: 1 V rms, ±.5 dB, 5-5000 Hz; Distortion less than 0.3% 20-3000 Hz, less than 0.5% 5-5000 Hz; Output impedance - 100 ohms

2.2 Compressor Output: 10 V rms max; Distortion less than 0.3% 20-3000 Hz, less than 0.5% 5-5000 Hz, Compressor OFF mode and ON mode, 0-20 dB compression, 10-3000 dB/sec; Output impedance - 50 ohm

2.3 Charge Output: 10 mV/g, 10 V p max; output impedance - 50 ohm

## 3. DC Outputs

3.1 DC proportional to LOG FREQ: 0 - 1.2 V (.4 V/decade); Linearity and stability 0.3 Hz or ±3%

3.2 DC proportional to FREQ: 0 - 10 V (2 mV/Hz); Stability ±2% or 1 Hz.

3.3 DC proportional to LOG AMPL (OPTIONAL): -3V to 0V (50 mV/dB); Accuracy ±.2 dB 0 to -40 dB, ±.5dB -40 to -60 dB

## 4. Compressor (AGC) Amplifier

4.1 Dynamic Gain Range: greater than 80 dB with compression indicated by front panel meter 0-80 dB

4.2 Compression Characteristic: Linear from 0 to 70 dB

4.3 Correction Accuracy: Essentially **zero** static error, 70 dB gain change results in less than 0.1 dB change in test level.

4.4 Speed: Automatically controlled in a continuous function of frequency from 10 dB/sec at 5 Hz to a switch-selected upper limit of 100, 300, 1000, or 3000 dB/sec at 5 kHz.

4.5 Turn On: Less than 7 sec from > 80 dB compression to full test level at 5 Hz.

4.6 Modes (Indicator lights for all modes)

ON: Compressor active for closed-loop operation. Compressor speed automatically controlled.

STBY: Compressor output smoothly reduced to more than 80 dB below full output

LEVEL CAL: Allows closed-loop operation with zero compressor output. Used for occasional calibration and check of operation.

OFF: Compressor inactive. Compression held at 0 dB.

## 5. Sweep Oscillator

5.1 Sweep Mode - logarithmic - continuous over 3 decades

5.2 Sweep Time - 1 to 99.9 minutes in 0.1 minute increments. Thumbwheel setting with digital display. Setting is independent of sweep frequency limits. Maximum sweep rate is 3 decades/minute.

5.3 Sweep Reversal Limits - Each settable with 10 turn controls. Low Limit: 5 to 5000 Hz. High Limit: Low limit to 5,000 Hz

5.4 Modes (all are pushbutton-actuated)

SWEEP: Initiates frequency sweep from MANUAL, RESET or HOLD mode. Indicator lights for direction.

REVERSE: Causes reversal of sweep direction.

HOLD: Stops frequency sweep. Indicator light.

RESET UP/DOWN: Holds frequency at value determined by upper/lower limit control. Indicating red LED's.

MANUAL: Holds frequency at value determined by COARSE and FINE frequency controls. Indicating red LED.

5.5 External Sweep - available at rear connector

5.6 Oscilloscope sweep (Option): Oscilloscope sweep synchronized to 3 periods of oscillator output

## 6. Programmer

6.1 Test Programs: As many as four segments with displacement and acceleration in any combination or sequence. Displacement selection shown by color-indicative pushbutton. Active segment shown by LED indicator.

6.2 Crossover Frequencies: Independently adjustable 5-5000 Hz.

6.3 Level Verniers: Ten-turn precision potentiometer with locking dial providing 1% settability of level without presetting operation. Displacement: .001 to .011 in p-p; Acceleration: .1 to 1.1 g peak.

6.4 Level Multipliers: X10 and X100 with color-indicating pushbuttons usable in any combination providing the following full-scale ranges: Displacement: .01, .1, 1, 10 in p-p. Acceleration: 1, 10, 100, 1000 g p.

6.5 Vibration Meter: 3 1/2 digit .56 in. high LED; monitors vibration level of active program segment.

Accuracy:

Disp: ±2% of reading ±0.1% of full scale, 5 to 1000 Hz.

Accel: ±1% of reading ±0.1% of full scale, 5 to 5000 Hz.

## 7. Acceleration Signal

7.1 Normalized 10 mV/g input - input impedance 47 kilohm

7.2 Charge Input: Adjustable for sensitivities 1-100 pC/g.

## 8. Interlocks

8.1 With compressor ON, MAX. OUTPUT turned CW, STBY mode is established if LEVEL CAL, OFF, A/D, X10, X100, oscillator RESET, or MAN. pushbutton is actuated.

8.2 With compressor in LEVEL CAL (or OFF) mode and MAX OUTPUT is CW, STBY mode is established if ON, OFF (or LEVEL CAL), oscillator RESET, or MAN pushbutton is actuated.

8.3 If SERVO goes to STBY for any reason and oscillator is in SWEEP mode, the oscillator automatically goes to HOLD mode.

## 9. Remote Control (Optional) Model RC

Separate unit has push-buttons to provide closed-loop operating functions once programmer controls are set. Push-buttons provided: Compressor ON, STBY, SWEEP, REVERSE, HOLD, RESET UP, RESET DOWN, MAN. Indicator lights are included to indicate active control functions.

## 10. Power

105-125/210-250 VAC 50-60 Hz 50 VA

## 11. Size

5.25" HIGH x 19" WIDE x 18" DEEP plus cables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Bulletin OSP4-82

# Model TA 250 Power Amplifier

## 1. General

The Model TA 250 is a solid state differential input DC coupled power amplifier rated at 2500 watts continuous duty output to a matched resistive load. Full output power can be obtained from DC to 5 kHz with slightly reduced output up to 10 kHz. (1) The amplifier provides exceptional performance with distortion less than 1.0 % and hum and noise down 80 db with respect to rated output. Air cooling with built in filter provides clean troublefree operation without need for water supplies, hoses, etc. Compact packaging techniques have yielded a high power completely self contained amplifier which is designed for portable or rack mounting applications.

## 2. Applications

The TA250 has been specifically designed for driving electrodynamic shakers from DC to 5 kHz. Both the resistive and reactive components of the shaker impedance vary radically over this frequency range. Thus the amplifier has been designed to operate with a very wide range of loads, without exceeding the output stage dissipation limits. This capability together with a differential input, DC coupling and portability suggests a variety of applications such as:

a. Long stroke shaker systems for ground vibration surveys of large aerodynamic structures.

b. Use with existing shaker systems to extend their low frequency response to DC.

c. Providing an AC Force output superimposed on a DC Force offset to simulate static and dynamic loads simultaneously. This feature also allows centering heavy loads while vibrating.

d. General purpose high power servo amplifier.

e. Portable power source for Sonar transducers.

f. Also available with integral output transformer to match other loads.

(1) For this system the input to the TA 250 is attenuated above 4 kHz to avoid overdriving the shakers and/or amplifiers. An input transformer is provided allowing operation from 2 Hz with isolation of amplifier reference from signal ground.

3. Output

This solid state amplifier is unique in providing a larger voltage output than other solid state DC coupled amplifiers. This allows matching higher impedance loads such as many existing shakers. Thus the TA250 will deliver 45 V rms and/or 55 A rms (1) to loads as small as 0.4 ohms without exceeding output stage dissipation. All ratings are based on continuous duty operation and should not be confused with pulsed ratings or peak ratings which are considerably higher.

4. Input

Differential input stage provides balanced phase inverted signals which are amplified by identical push-pull stages in each half of the amplifier. Balanced circuitry and DC feedback loop effectively cancels time-temperature drift at the output. All solid state components are silicon type for the utmost in reliablility and temperature stability. Output stages are operated at 30% of rated current for maximum reliability.

5. Protective Features

To insure reliability the amplifier is positively protected against overdrive under any condition. Since the load impedance can vary over wide limits the amplifier is fully protected against damage due to overvoltage drive, overcurrent drive and even short circuit conditions. Overcurrent protection is obtained in three ways. First the driver stages are electronically current limited at 140% of rated output. This provides instantaneous current clipping for transient overdrive or short circuit conditions. Secondly, optically coupled transistors monitor output currents and drive an SCR and high speed relay to shut the amplifier down at 100% of rating to prevent continuous overdrive. The two emitter fuses associated with this circuit are monitored so fuse loss will also cause shutdown. Finally the output stages are fused with very fast acting "Limitron" fuses.

(1) In this system current limits adjusted to 56 A rms, 51 A collector current.

5. Protective Features- continued

Voltage clipping is prevented by RE105 and associated circuitry. Q57 senses the sum of the preamplifier phase opposed outputs. When clipping occurs the voltages are distorted resulting in a net negative sum which turns on Q57 and RE105 thereby shutting the system off.

Overtemperature protection is provided by thermal switches mounted directly on the output stage heat sinks. This feature protects against fan failure, clogged filters, restricted air flow, and high ambient temperatures when rack mounted. The amplifier is further protected against overtemperature by having the air inlet on the front panel thus making the cooling independent of ambient temperature in the rack.

Protection to prevent operation in the event of loss of one phase of the three phase line is also provided by RE 105 and associated circuitry. A three phase rectified signal, biased to a positive voltage, is provided on PC2. Loss of one line phase results in negative going pulses which couple through an isolating diode and resistor on PC4 to Q57 base, thus turning on Q57 and energizing RE 105 and thereby shutting the system off.

6. Construction

The signal circuitry of the TA 250 consists of three sub-assemblies; preamplifier, driver, and output. The preamplifier is printed circuit construction and mounted on a plug-in card for easy checking or replacement. Transistors are mounted on plug-in sockets.

The output stages are all mounted on an unusually compact and efficient heat sink with integral blower. Octagonal design places the transistors on outside surfaces for easy access while the heat transfer surfaces extend inward forming an enclosed duct for the heated airstream. Filtered cool air is drawn in through the front panel and exhausted in the rear.

The driver stages are mounted as a separate assembly under the chassis. All components are arranged for easy access to simplify servicing.

## 7. Circuitry

The TA 250 is a DC Power Amplifier with push-pull class B output stages. In a typical AC amplifier with Class B output stages the output transformer is used to alternately connect one-half of the amplifier to the load and then the other. This requires two primary windings, each of which is used only half of the time. Although inefficient, this is the best compromise.

With a DC amplifier the output transformer is omitted and typical class B operation would require that the load consist of two windings, each of which is alternately idle for one-half cycle. In addition, the quiescent current of the output stages would flow in the load. Since the shaker driver coil is normally a critical design item these requirements are intolerable. Therefore, special amplifier circuitry is required to allow retaining the advantages of Class B output stages without requiring an inefficient load design. This is accomplished by using two DC power supplies which are floating with respect to amplifier reference. Each power supply is used alternately during one-half cycle. This design results in a balanced output with respect to amplifier reference. Since amplifier reference is isolated from ground, a ground fault on an output bus will not cause damage or misoperation.

### 7.1 Power Supplies

A three phase transformer with four secondary windings, each rated at 54 V provides a plus and minus supply for the preamplifier and driver stages and two identical high power supplies for the output stages.

The preamp supplies are essentially the same and are located on a plug-in circuit board under the chassis. Each supply is 3 phase to minimize ripple. A series regulating power transistor for each supply is located on a common heat sink. Regulated output of + 45V and - 45V @ 1/4 A are provided.

The high power supplies are floating with respect to ground and are driven up and down with the load. Each supply has one group of three rectifiers on one-half of the output heat sinks and the other three rectifiers are located on an adjacent heat sink.

7.1 Power Supplies Continued

The power transformer has seven taps on each primary coil. In addition the coils may be connected in Y or delta. This provides taps for input voltages of 340 V to 508 V for Y or 196 V to 294 V * for delta connections.

7.2 Signal Circuitry

7.2.1 Preamplifier

The preamplifier mounted on the PC card is a typical differential DC amplifier. Transistors $Q_1$ and $Q_2$ are buffer stages to provide the desired source impedance for feedback to the base of $Q_3$ and $Q_4$. Transistors $Q_3$ and $Q_4$ form a conventional differential circuit and provide phase opposed signals at each collector for an input at either base. The collector current in these stages is approximately 40 microamperes to minimize DC drift. In addition $Q_3$ and $Q_4$ are mounted on a common heat sink to cancel temperature drift effects. Transistor $Q_5$ provides a constant current source for $Q_3$ and $Q_4$.

Transistors $Q_7$ and $Q_8$ provide an additional stage of amplification. They are PNP stages which invert the DC offset of $Q_3$ and $Q_4$ and bring the DC operating point of $Q_9$ and $Q_{10}$ back to essentially zero volts. The collector currents of $Q_7$ and $Q_8$ are summed in an 11K resistor and fed to the base of of $Q_6$. Any change in the sum is sensed by $Q_6$ wich changes the current through current source $Q_5$ in a direction to correct the change. This feedback circuit tends to keep the total collector current from $Q_7$ and $Q_8$ constant but does not prevent drift from side to side. Also note that this summing network provides large AC feedback. Although $Q_6$ performs all of the above functions they could also be performed by the external feedback loop. The main function of $Q_6$ is that its DC temperature drift tends to cancel the drift of $Q_5$. For this reason $Q_5$ and $Q_6$ are mounted on a common heat sink. Stages $Q_9$ and $Q_{10}$ are current amplifying emitter followers with constant current sources $Q_9$ and $Q_{10}$ providing high impedance dynamic loads.

*50 Hz Input voltage 338 to 415 for Y and 195 to 240 for Delta, using T69-50 50 Hz power transformer.

7.2.2 Driver

The driver stages $Q_{15}$ and $Q_{16}$ provide further current amplification with the constant current sources $Q_{13}$ and $Q_{14}$ again providing a high impedance dynamic load. However, these stages also perform the important function of current limiting to the output stages. This is accomplished by making the driver stages PNP while the output stages are NPN. Thus the output stages deliver current in response to current fed <u>into</u> their bases. This current must come from $Q_{13}$ or $Q_{14}$ since $Q_{15}$ and $Q_{16}$ cannot deliver current flow in this direction. Therefore, if $Q_{15}$ or $Q_{16}$ are severely overdriven into cutoff the maximum current that can be delivered to the finals is that available from the constant source $Q_{13}$ or $Q_{14}$. This is adjusted to a value which will provide approximately 140 % of rated output.

7.2.3 Output Stages

The output stages consist of cascaded emitter followers driving 15 paralleled transistors on each half. A 0.5 ohm resistor in series with each emitter equalizes the load distribution and also limits the instantaneous current in case one transistor should fail with a collector to base short. The very fast acting KAW10 fuses provide short circuit protection.

7.2.4 Metering

Two front panel meters monitor the collector current in each half of the amplifier, which is also a good measure of the output I. The meters are monitoring the average current. To convert the meter readings to RMS output current:

Reading A or Reading B x 1.1 = Amps RMS output.

7.2.5 Input Transformer and Signal Reference Isolation

A signal input transformer is provided to allow complete isolation of the power amplifier signal reference from the external input signal source reference. Also, the power amplifier reference is connected to the chassis via a 1 k ohm resistor, allowing it to assume a voltage different from the chassis ground potential. Thus, it is possible for amplifier to tolerate a fault to ground from either of its output terminals without misoperation or overload.

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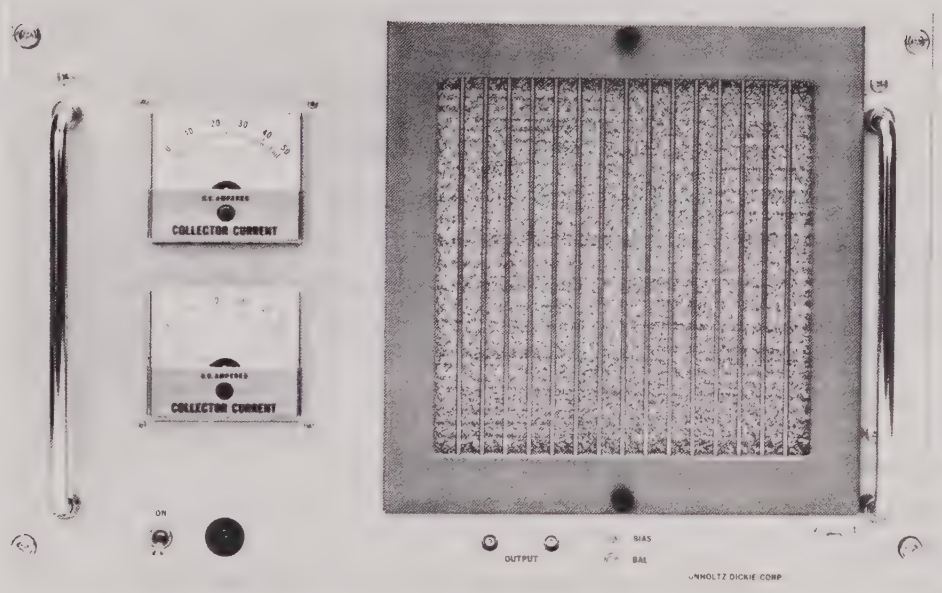
VIBRATION TEST EQUIPMENT

# Solid State Power Amplifier TA100A/TA250A




- **DIRECT COUPLED**
- **ELECTRICAL LOAD CENTERING**
- **ULTRA LOW DISTORTION**
- **OVERLOAD PROTECTED**
- **LOW VOLTAGE OPERATION**
- **AIR COOLED**
- **MODULAR, RACK MOUNT CONSTRUCTION**
- **TA100A: 1.5 KVA OUTPUT TA250A: 2.5 KVA OUTPUT**

The Model TA100A and TA250A Solid State Power Amplifiers are designed to furnish direct coupled power for electrodynamic shakers, providing output power ratings of 1500 VA and 2500 VA, respectively. These amplifiers feature the ruggedness of silicon, alloy junction transistors and a mature third generation circuit design with more than 15 years of reliable field history.

**DIRECT COUPLED OUTPUT:** Major performance advantages are gained by utilizing direct coupling at the output rather than a matching output transformer. Direct coupling makes possible the following desirable operating characteristics: (1) DC electrical load centering which permits full one inch shaker stroke even with heavy test loads; (2) increased shock pulse testing capability by utilizing DC offset of the shaker armature; (3) combined static and dynamic testing; and (4) absence of low frequency transformer roll-off.

**Eight basic amplifier configurations are available to provide optimized performance for the following U-D shaker/PA combinations.**

| AMPLIFIER MODEL | SHAKER | COMMENTS |
|---|---|---|
| TA100AF | 20 | DC field power for shaker taken from P.A. supply. General purpose. |
| TA100A (CAL) 1/2<br>TA100A (CAL) 3/4 | 106A-1/2<br>106A-3/4 | DC to 10 kHz response, special velocity feedback circuitry in "-3/4" model provides ultra-low distortion. Used in U-D calibrators only. |
| TA100AMI-4<br>TA250AMI-4C<br>TA250AMI-6 | 4<br>4C<br>6 | Includes DC response and selectable current feedback for constant force operation. Calibrated force signal provided. Used only in U-D modal systems. (see separate modal shaker bulletins). |
| TA250A | 20H<br>T102<br>T206 | Standard configuration for 2.5 kVA output. General purpose. |
| TA250AD | 206 | Series connection of two TA250A provides dual PA operation at 5 kVA output. General purpose. |

## SPECIFICATIONS

**Power Output:** TA100A: 1500 Volt Amps; TA250A: 2500 Volt Amps

**Output (Volts/Amps):** TA100A: 45V rms/34 A rms; TA250A: 45V rms/56 A rms

**Frequency Response:** ±0.5 dB 5 Hz to 5 kHz (DC coupling, input to output, provided for modal systems.)

**Output V.A.:** Rated output from 5 Hz to 3000 Hz, decreasing to 45% of rated voltage and current at 0.5 Hz and 35% of rated voltage and current at DC with shaker load.

**Harmonic Distortion:** 5 Hz to 2 kHz < 0.5%, 2 kHz to 5 kHz < 0.7%, with shaker load at full system rated performance.

**Hum and Noise:** At least 80 dB below rated output

**Output Stage Dissipation:** Transistor rated dissipation is 3.6 kW for TA100A and 6 kW for TA250A

**Input Impedance:** Over 10 k ohms

**Input Signal:** Matched to signal source, 7 V rms typical for full output.

**Circuitry:** All solid state

**Metering:** Two front panel meters monitor current in each half of the amplifier output stage.

**Protective Circuits:** Current limited driver stages prevent overdrive in output transistors. Positive short circuit protection, with fast acting "limitron" fuses. Output stages monitored with peak responding current relays to de-energize the amplifier on overcurrent. Output voltage clipping sensors protect against over voltage. Thermal switches on the output stage heat sink de-energize the amplifier at a conservative 150° F. Amplifier is de-energized if one leg of three phase power is lost.

**Zero Set:** Front panel trimpot provides DC centering force at the shaker. Up to ±10% of maximum output is obtainable.

**Cooling:** Integral fan draws filtered cool air thru the front of the amplifier. The air filter is removable from the front for cleaning.

**Power Requirements:** 3 phase, 60 Hz, with taps from 200V to 500V. TA100A requires 3 kVA, and TA250A requires 4.5 kVA. 115 volt single phase at 1 amp power is required for fan and interlocks. 50 Hz optional.

**Size:** 19" rack mounting with 12 1/4" panel height. 19 1/2" depth plus 2 1/2" for cable connection at rear.

**Weight:** TA100A, 175 pounds; TA250A, 200 pounds.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Bulletin TAA-82

IMPORTANT

The shaker blower rotation should be according to the arrow on the blower. It should be checked on initial startup and whenever the system is relocated or the three phase power line is changed.

Note that proper air flow direction does not indicate proper rotation; the direction of flow will be the same for right or wrong blower rotation. Visually check rotation of blower as it coasts to a stop.

6/27/74

GROUND LOOPS

In any system, grounding the signal circuit at more than one point results in a ground loop or loops. Electromagnetic fields from power transformers etc, generate voltages in these loops. The generated voltage results in a current flow such that the IR drop is equal to the generated voltage. In most cases the major resistance (R) in the loop is in the signal common (usually the shield in the coax cable) between instruments. Therefore, the signal common is at different potentials if there is an IR drop in this connecting lead.

In order to minimize this problem it is desirable to ground the control instruments at only one point. To facilitate this all U-D instruments are designed with the signal common isolated from the chassis. A rear switch labelled EXT-INT allows connecting signal common to chassis (INT GND) or isolating it (EXT GND). When using U-D instruments set all instruments but one on EXT GND. Usually grounding the last instrument before the P.A. gives the best results.

When using control instruments from other manufacturers they often have permanently grounded signal common. In this case set all instruments possible in the isolated mode.

When the control instruments are located remote from the P.A. long lines between instruments result in larger loops and more serious problems. In this case always route a large ground cable #8 or greater, adjacent to (close coupled) the coax between the consoles. Secure the ground cable to chassis at both ends as close to the coax termination as possible.

## D. OPERATING INSTRUCTIONS

1. Before attempting to start the system, check that:
   a. Water shut-off valve is full open (if applicable).
   b. Single phase power is turned on (if applicable).
   c. 3-phase power at customer installed disconnects are turned on.
   d. Amplifier Power Switch is turned on and, if applicable, I-V switch is in desired position. (Do not change I-V switch if console is in "Operate"
2. Turn the interlocked gain control* down (full CCW). This trips the interlock switch which will enable the Operate button.
3. Push the "Power ON" button on the meter panel. The button will light and the console fans and instruments will come on. If the light does not come on, re-check the single phase power source. If the light comes on when the button is pressed, but goes out when the button is released, check for an open door interlock switch.
4. After approximately 30 seconds time delay, the "STAND-BY" light will light.
5. Push the "OPERATE" button. This causes power to be applied to the amplifier, field supply and shaker blower. The "OPERATE" button should light and the red pilot on the front of the amplifier will light. If the red light and Operate light come on momentarily and then go out, this could indicate that one phase of the three phase line is missing. Check fuses in the console and incoming three phase power. If the Operate light goes out as soon as the Operate button is released, check that 3 phase power to console and blower are both on. If the Operate light does not come on at all, check that the interlocked gain control is fully CCW and that the Amplifier power switch is On.

* Typically this is the "Amp Gain" control for systems without a Servo-Programmer, or the "Max Output-V" control on the Servo-Programmer for systems with this instrument. In systems with a Sine-Random Selector Panel, the "Amp Gain" or "Random Gain" control is also interlocked, and the selector switch must select either Sine or Random (not left in the center "off" position).

Typically, with a shaker load one of the meters on the amplifier will swing up scale approximately 3 to 10 amps and then subside so that both meters read between 0.5 and 1.5 amps.

If either meter reads greater than 3 amps statically after 10 minutes, adjust the BAL control on the amplifier so both meters read the same and then adjust the BIAS control on amplifier to provide 1.0 amp quiescent current.

The two front panel meters on the amplifier provide an indication of the average load current.

For sinusoidal drive the RMS load current is the average of the two meter readings multiplied by 1.1, bias current neglected.

The amplifier output voltage can be monitored at the front panel BNC connectors. The hot portion of each BNC is connected to an output bus via a 1.5K resistor. The BNC shell is connected to the amplifier chassis rather than signal reference to maintain reference isolation. If output voltage is to be monitored at low signal levels, a differential measurement between the two BNCs will reject the reference to chassis noise.

If a DC unbalance is required at the load it may be adjusted using the amplifier BAL adjustment. This is particularly useful for centering shaker tables when large loads are attached. Typically DC collector currents up to about 1/3 full AC value may be used, corresponding to a DC force of about 10% of rated peak sine force.

6. This system has a fixed field supply. No operating adjustments are required. Normal field current is 37 amperes after warm up as indicated on the Field meter.

7. The system is now ready for operation. To drive the shaker, turn up the Amp Gain Control or operate the Servo-Programmer as described elsewhere.

8. At any time, the system can be put in a standby condition by pushing the "STAND-BY" button. This turns off the power amplifier

3-phase power and the field supply. However, the instruments remain on, permitting re-startup without instrument warm-up. At any time, operation may be resumed by pushing the "OPERATE" button. The interlocked gain control must first be turned down or the "OPERATE" light will not come on.

9. Rated performance for this system is 500 pounds force, except as limited by stroke and maximum velocity. See performance curve Q 4028. Maximum collector current is 50 amps. Driving the system beyond rating will generally trip protective devices putting the system in the STANDBY condition.

The following will shut the system down:

SHAKER:

a. Exceeding the 1 inch d.a. table displacement will trip the shaker overtravel switches.

b. Loss of shaker cooling air will cause the shaker air flow switch to open.

c. Shaker temperature above 200° F will trip the shaker thermal switches.

AMPLIFIER:

a. Overcurrent

Although the amplifier is electronically current limited, additional protection for the load is provided by overcurrent relay RE103. Optically coupled transistors Z1 and Z2 monitor the output current in each half of the amplifier and cause RE103 to shut the system down at approximately 51 A Coll. cur* If this output current is reached during operation relay RE103 will open the interlock string and thereby remove 3 phase power from the amplifier. Below approximately 3 Hz, peak current pulses may blow the output fuses in the amplifier before the relays trip.

* Approx. 56 A rms.

This is because the fuses respond to the rms current at high frequencies, but peak currents at low frequencies. When the output fuses blow, relay RE103 will shut the system down at less than normal full output current, or immediately upon application of three phase power, depending on which output fuses are blown.

b. Voltage Clipping

Should the amplifier be driven to the point where voltage clipping occurs contacts on relay RE105 will open the interlock string and shut down the system. Relay RE105 is transistor controlled by Q57 which monitors the input drive voltage of Q17 and Q18. When voltage clipping occurs at the output, the feedback circuitry tries to correct for it and causes a net slightly negative pip signal at the waveform peak when the two drive signals to Q17 and Q18 are summed. It is this signal which results in Q57 conducting and causes contacts on RE105 to open the interlock string.

c. Thermal Protection

Overtemperature protection is provided by two thermal switches mounted directly on the output stage heat sinks. The thermal switches are part of the interlock string. This feature protects against fan failure, clogged air filter, restricted air flow, and high ambient temperatures when rack mounted. The amplifier is further protected against overtemperature by having the air inlet on the front panel thus making the cooling independent of the ambient temperature in the rack.

d. 3- Phase Interlock

In the event of loss of 3-phase power relay RE102 de-energizes and opens its contact set which is part of the interlock string. If one phase of the three phase line is lost, Q57 will energize RE105 and open the interlock string.

CONSOLE:

The door at the rear of the console operates an interlock switch. Should the door be opened when the system is in the operate condition, the system will shut itself down.

F-3(a)

UNHOLTZ-DICKIE CORPORATION
2994 Whitney Avenue
Hamden, Connecticut

# Disassembly Instructions

## MODEL 100 and 102 SHAKER

1. Remove fiberglass hood. Be careful to remove accelerometer lead and push it thru the hole in the hood.

2. Remove the 1/4" water tubing on the top disc by disconnecting the fittings.

3. Disconnect the electrical connections on the terminal strip on the top disc.

4. Remove the two bumpers and the overtravel switch which are mounted on the pies. Be careful to retain the shims under these pieces.

5. Remove the #10-24 socket head cap screws in the eight pies (one bolt per pie segment).

6. Remove the eight bolts, 3/8-16 socket head cap screw holding the top disc to the flanged disc.

7. The Top Disc is now ready to be lifted out. This is best done by inserting 2 eye bolts into the hole with the 3/8-16 set screws (remove the set screws). The moving element will come up with the Top Disc so the Top Disc must be carefully lifted straight up. It helps to use a chain hoist or portable lift. Also, if two long threaded rods are put into the 3/8-16 threads in the flanged disc, the Top Disc will be guided straight when lifting.

   As the Top Disc is being lifted the electrical leads should be pushed down thru the holes. After lifting 3 or 4 inches, the Top Disc should be held while the driver coil lead connections to the current spring assemblies (two) are disconnected.

8. The Top Disc can be completely removed at this point, giving access to the top field, and the thermal switches.

9. Remove the top field coil. Be sure the lead wires are marked so that they will be reconnected the same polarity at assembly.

10. To remove the bottom field coil, next rotate the remainder of the shaker 180 degrees on the trunnions and lock the trunnion clamps. The hub, or bottom steel part, should now be on top, with the shaker cable coming out of a box on it.

11. Remove the eight bolts 3/8-16 socket head cap screws holding the hub to the flanged disc.

Disassembly Instructions

MODEL 100 and 102 SHAKER

12. Hoist the hub straight up, feeding the lead wires thru the hole in the flanged disc as it is raised. The cable and hub stay together as one assembly.

13. The lower field coil is now accessible for servicing.

# ASSEMBLY INSTRUCTIONS

## MODEL 100 and 102 SHAKER

1. In general, the steps are the reverse of the steps given in the disassembly instructions. The main difference is that the armature winding must be aligned in the magnet air gap.

   The alignment is best accomplished by dropping the top disc and moving element assembly back down on the shaker flanged disc, leaving the 3/8" bolts out. Also, the eight pie segments should be removed. Then insert four strips of laminated phenolic ("Micarta") .020" thick by 1/4" wide by 8" long, down into the air gap along side of the armature winding O.D. They will go into the air gap about 3", and the other ends will stick up out past the top of the moving element, in the holes left by the pies. They should be spaced around the circumference at $90^{\circ}$ intervals. These spacers give the armature winding the proper alignment. At this point, the top disc can be bolted down. Remove the four Micarta strips. The moving element should feel free to move up and down.

2. Next, the pie segments can be inserted. It will be necessary to raise the moving element up against the springs to drop the pies in.

3. Then retrace the disassembly steps.

Fig.

# MODEL 100 SHAKER

| PART NO. | ITEM | QUAN. PER SHAKER |
|---|---|---|
| 1032 | HOOD | 1 |
| 2157 | EPRA | 8 |
| 1084 | CLAMP PLATE | 14 |
| 1033 | HEX SUPPORT HOOD | 12 |
| 1017 | SHEAR MTS. | 2 |
| 1027 | 10-24 INSERT SM. | 12 |
| 1135 | 10-24 INSERT LGE. | 1 |
| 1108 | INSUL. BLACK UPPER CLAMP | 4 |
| 1105 | STEEL BLOCK UPPER CLAMP | 4 |
| 1034 | SCREEN HOOD | 1 |
| 1011 | TOP DISC | 1 |
| 1172 | HUB MACH. | 1 |
| | ISOMODE PADS | |
| 1009 | FLANGED DISC | 1 |
| 1013 | TOP CYLINDER | 1 |
| 1015 | PIES | 1 |
| | | |
| 1171 | OUTER CYLINDER | 1 |
| A1154 | MOVING ELEMENT | 1 |
| 1005 | WEB | 1 |
| 1016 | BOBBIN | 1 |
| 1630 | SWITCH BLOCK DOWN | 1 |
| 1041 | TRUNNION CLAMP | 2 |
| 1040 | TRUNNION | 2 |
| 1099 | EPRA SPACERS | 8 |
| 1064 | SPACER INSERT SMALL | 12 |
| 1145 | END CLAMP SPACERS | 4 |
| 1157 | CURRENT CLAMP RT. & LF. | 2 |
| 1065 | SPACER INSERT LARGE | 1 |
| 1057 | UPPER SUSP. BLOCK | 8 |
| 1025 | STEEL BLOCK COIL CLAMP | 4 |
| 1026 | INSUL. BLOCK, LOWER CLAMP | 4 |
| 1048 | BUMPER UPSTROKE | 2 |
| 1110 | CURR. CON. OUTER | 3 |

MODEL 100 SHAKER

| PART NO. | ITEM | QUAN. PER SHAKER |
|---|---|---|
| SK1011 | WRENCH | 1 |
| A3336 | FLAIR NUT FITTINGS FIELD COIL | 4 |
| B3337 | FIELD COIL UPPER | 1 |
| B3338 | FIELD COIL LOWER | 1 |
| A1146 | 100 PIE TURNED SCREW | 4 |
| 1087 | TERMINAL BOX | 1 |
| 1088 | TERMINAL PLATE | 1 |
| 1113 | TURNED SCREW 8-32 x 3/4 | 4 |
| 1112 | S P BUSHING | 4 |
| 2686 | MICARTA WASHER | 4 |
| 2098 | PEEKABOO CURR. SPR. ASSY | 8 |
| 1910-5 | DWYER AIR SWITCH | 1 |
| A1168 | CABLE ENTRY PLATE | 1 |

## MODEL 100 EXTERNAL BLOWER

| PART NO. | ITEM | QUAN. PER SHAKER |
|---|---|---|
| 7C741 | BLOWER | 1 |
| | 3" IDX 20 FT. DUCT | 1 |
| 2107 | PEDESTAL DUCT ADAPTER | 1 |
| B1660 | BLOWER DUCT ADAPTER | 1 |
| D1165 | BASE | 1 |
| D1038 | PEDESTAL | 1 |
| D2105 | PEDESTAL | 1 |

## Fixture Design

### Some Comments

Vibration test fixtures come in such a large variety of sizes and shapes that it is difficult to give general statements that can be useful for a particular design. However in working with our customers who are newcomers to the field of vibration, we have found a common problem which we feel warrants pointing out. Customers with long experience in fixture designs and applications will of course be aware of the problem to be discussed here and will have overcome it.

Many newcomers to approach fixture design from the viewpoint of static strength and stiffness. The fixture and load weight are estimated and multiplied by the 'g' level of the test. This yields the force transmitted. This force is usually quite modest in terms of static strengths so that the designer then proceeds to clamp the specimen to the fixture and the fixture to the shaker table with a few bolts and clamping sections which are entirely adequate to cope with these low static forces. This approach fails to account for the dynamic conditions that occur at the higher frequencies encountered in most vibration tests.

Usually when a fixture is designed with only static loads in mind, a very severe major resonance occurs within the frequency range of the test. The clamping and bolting arrangement, while adequate statically, turns out to be very soft or compliant when analyzed dynamically. In other words the mass of the test item and fixture is resonant on the soft springs consisting of the clamping arrangement to the shaker table

There are at least two major objections to this resonant condition. The first is that the test item does not receive the correct 'g' level as controlled by the accelero meter in the shaker table. Due to the resonance, the 'g' level at the test item can be many times higher than the shaker 'g' read on the meter. This results in severe overtesting, sometimes damaging the specimen.

The second is that due to the resonance, there usually occurs a frequency where extremely high amplifier power is required to maintain constant 'g' at the shaker table. This can be observed by noting when the driver ammeter swings full to the maximum and pegs the needle. This results in severe overdrive, high distortion, blown fuses, or tripping overcurrent or overvoltage relays.

The cure is to design fixtures with the dynamic problems in mind. In practice, this means making the clamps and hold down bolts stiff relative to the masses involved, so that the resonance of the spring-mass system is as high as possible, preferably above the operating frequency.

A second cure is to control from an accelerometer located up on the fixture or test item. This is usually less convenient, for the accelerometer must be moved each time the fixtures are shifted on and off the table. It is sometimes the only solution, as for example, if the test item is so large that the resonance cannot be pushed above the operating frequency.

The following section describes some typical static fixture designs we have encountered, and the recommended changes to make them dynamically satisfactory.

Case 1

The test items were small electrical components clamped to rectangular aluminum plates 5" x 5" x 1/2". These plates were then mounted on the fixture which was bolted permanently to the shaker table. The first design for the fixture was a welded box structure of 3/8" thick welded aluminum plates as in Fig. 1. It was impossible to run the tests because of the severe resonance below 1000 cps, and 'g' levels on the test items were over 10 times as great as measured by the shaker accelerometer. The solution was the redesigned fixture shown in Fig. 2. This fixture was solid cube of magnesium, with drilled holes to remove weight. Also more of the hold down bolts into the shaker table were utilized. The resonance for this new fixture was moved up over 2 Kc and no testing difficulties were found.

Case 11

In this test the specimen fitted into a cubical aluminum fixture. The fixture then was fastened at four points to a 1/4 inch thick aluminum adapter plate. The adapter plate was fastened at four other points to the shaker table This adapter plate was in effect a very soft spring and a severe resonance occurred. Two solutions were possible. The fixture could be redesigned to bolt directly to the shaker table, using more than four bolts if possible. The second was to redesign the adapter plate. It was made of magnesium, about 1" thick. It was tied to the shaker table using all 13 holddown bolts available on that shaker. Additional bolts were added from the fixture to the plate. Figs. 3 and 4 show the before and after for this case.

Summary

Some of the points brought out by the above cases are.

1. Use as many of the hold down bolts to the shaker as possible

2. Use magnesium instead of aluminum. Magnesium weight is about 65% of aluminum. Plate thickness can be made much thicker and stiffer with magnesium.

3. Avoid thin plates that can act as leaf springs, instead use solid, smaller fixtures. Weight can often be kept down by honeycombing with drilled holes, without affecting stiffness.

4. Use a minimum of joints or mating members. The omission of an intervening adapter plate almost always increases stiffness.

5. Two flat mating surfaces can be helped by a layer of silicone grease on the mating surfaces. This grease results in an adhesive action similar to the oil on Johanson gage blocks. This particularly effective at high frequencies.

6. Use as many bolts, as possible, spaced as close as possible in bolting specimen to fixture, and fixture to adapter plates.

7. The fixture weight should not be the maximum allowed by the system performance. By making the static weight somewhat less, it allows for the higher dynamic loads that occur around resonance frequencies.

Several of the following references are helpful on vibration theory and dynamics of structures. Some give formula for stiffness of plates, beams etc. which are useful in fixture design

1. "Handbook of Shock and Vibration"; Harris McGraw Hill

2. "Mechanical Vibrations"; Den Hartog 3rd Ed. McGraw Hill

3. "Mechanical Vibrations", Thomson, Prentice Hall

4. "Vibration and Shock Isolation", Crede, Wiley

5. "Vibration & Shock Test FIXTURE DESIGN"; Klee, Kimball and Tustin, available from TEST ENGINEERING & MANAGEMENT, 61 Monmouth Road, Oakhurst, N.J. 07755

POOR DESIGN

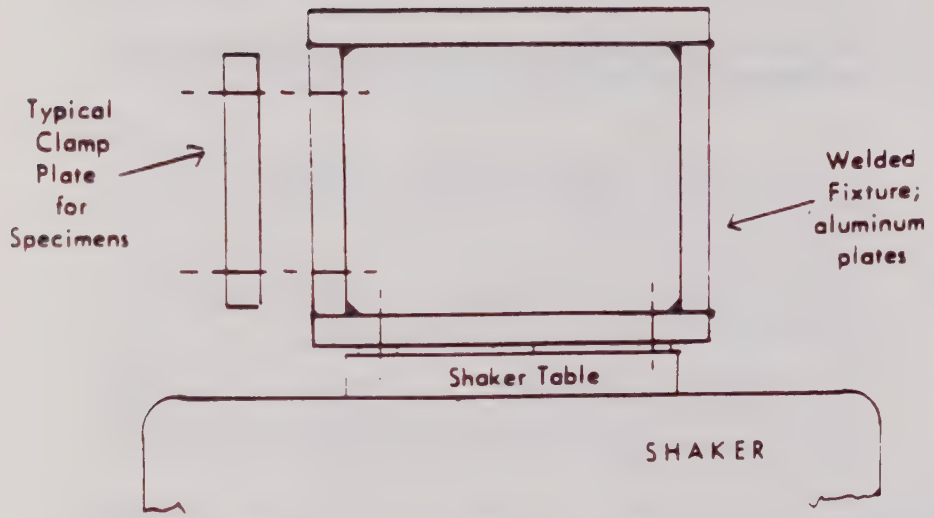



Fig. 1

REDESIGNED

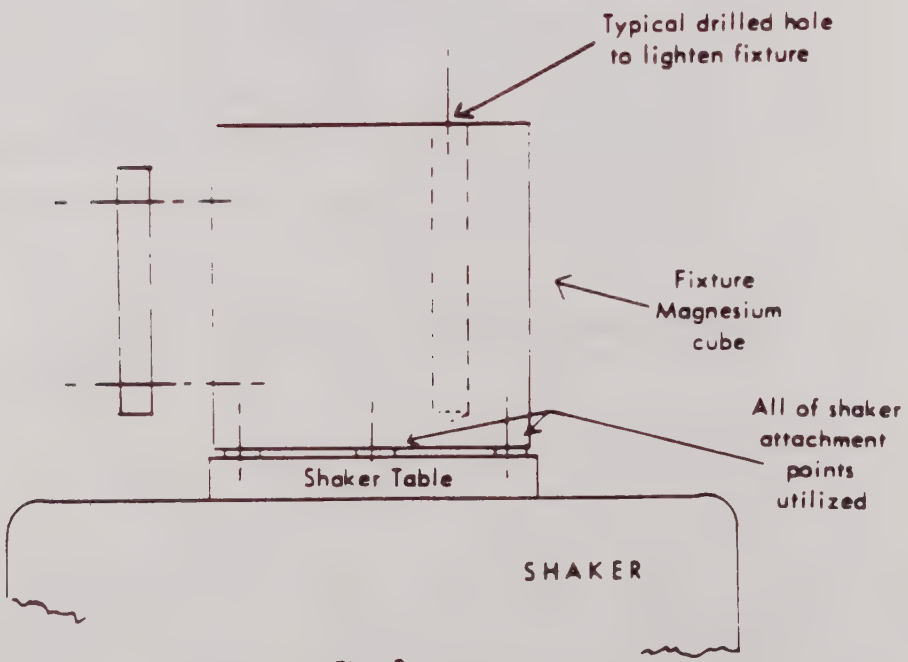



Fig. 2

N-5

## POOR DESIGN

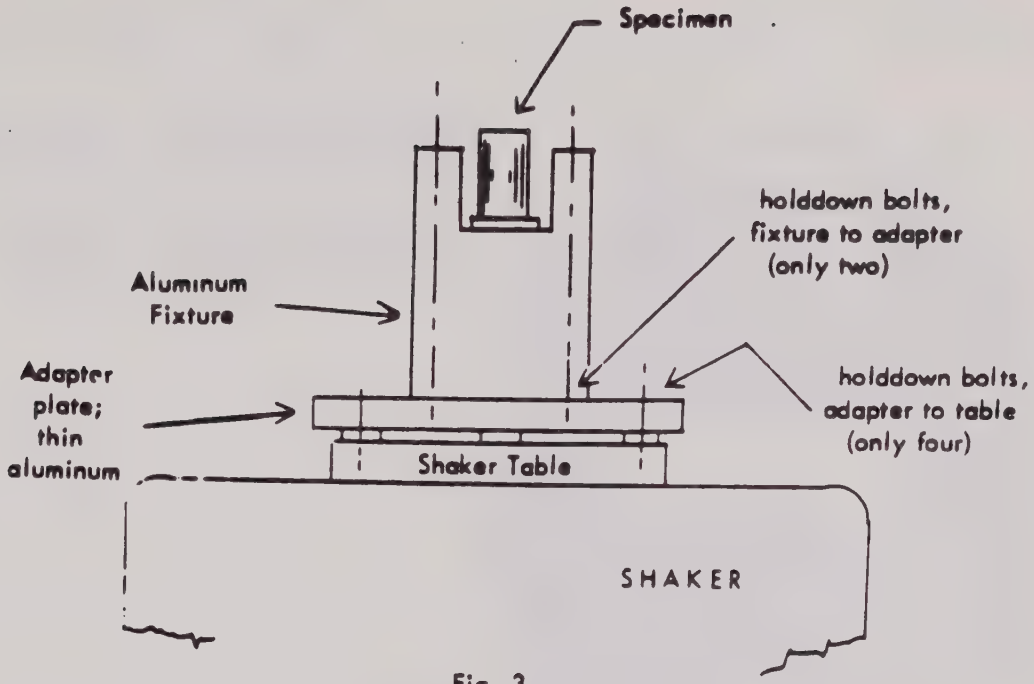



Fig. 3

## REDESIGNED

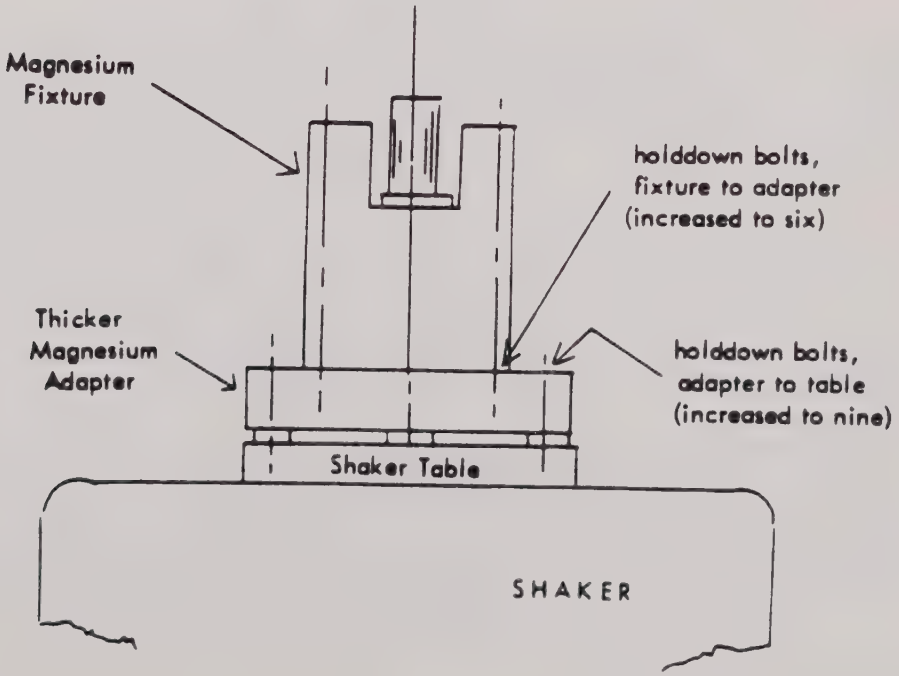

Magnesium Fixture
holddown bolts, fixture to adapter (increased to six)
Thicker Magnesium Adapter
holddown bolts, adapter to table (increased to nine)
Shaker Table
SHAKER

Fig. 4

**UNHOLTZ-DICKIE CORPORATION**

**VIBRATION TEST EQUIPMENT**

# 100 SERIES SHAKERS

- ★
- ★
- ★
- ★

## 100 SERIES

### GENERAL DESCRIPTION

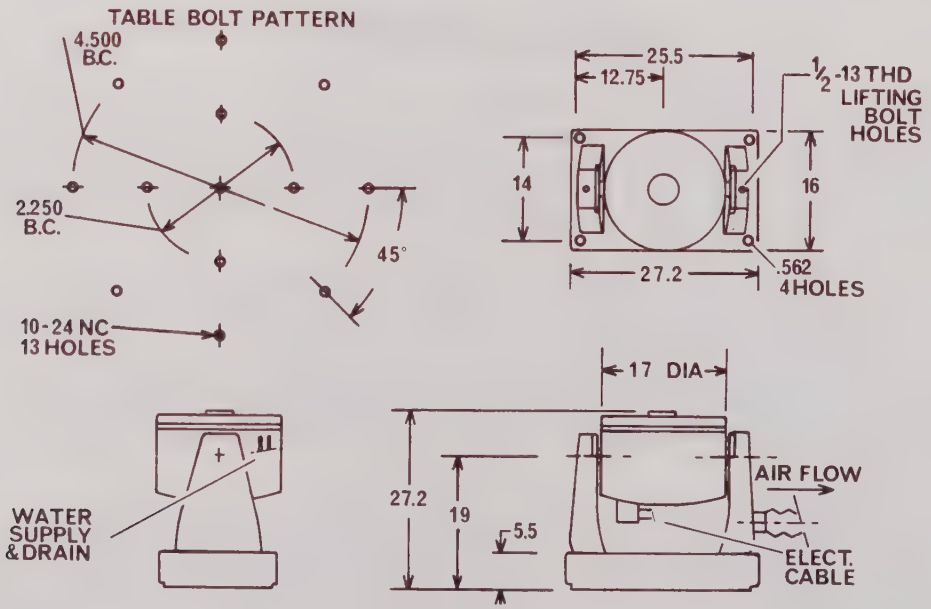
Unholtz-Dickie 100 Series Shakers are designed for high frequency testing of small to medium size payloads, as well as a variety of general purposes applications. The high resonant frequency of the shaker armature allows operation up to 5,000 Hz and higher. Exceptional low frequency performance is also provided when the power is supplied by an Unholtz-Dickie direct coupled, solid state power amplifier (see separate bulletin).

The magnetic circuit is a double ended design, providing parallel flux paths from above and below the magnetic air gap. This configuration gives maximum magnetic flux linkage with the armature coil and assures minimum amplitude non-linearity. The iron shaker body completely surrounds the electrical field coils, thereby minimizing external leakage flux at the table surface. By comparison, permanent-magnet field configurations which form the outside of the shaker body result in high external magnetic fields. This undesirable feature is eliminated by using a double ended, electrical field coil design.

The armature suspension system is designed for continuous operation at one inch peak-to-peak displacement, and has no critical operating frequencies. The suspension consists of bonded rubber and metal mounts used in shear for axial support of the table, and highly damped laminated flexures in two planes for stiff radial restraint. All relative motions in the suspension are taken across rubber and laminated flexures, thereby eliminating fragile small parts, critical clearances, and changes in adjustments due to wear of bearing surfaces after extended operation.

## SHAKER SPECIFICATIONS

| | |
|---|---|
| FORCE RATING: | 500 lbs peak sine — 400 lbs rms random |
| ARMATURE RESONANCE: | 4300 Hz, nominal with no table load |
| ARMATURE WEIGHT: | 5.3 lbs nominal |
| TABLE DIAMETER: | 4½ inches (outer bolt circle) |
| SUSPENSION STIFFNESS: | 225 lbs/inch |
| DISPLACEMENT: | 1 inch, peak-to-peak |
| CROSS AXIS MOTION: | Maximum of 15% perpendicular and parallel to trunnion axis with centered 1.8 pound load, 5 Hz to 2000 Hz. |
| OVERTRAVEL PROTECTION: | Limit switch plus 1/8 inch energy absorbing cushions. |
| INTERNAL ACCELEROMETER: | Provisions are made for installation of an accelerometer under the table center load attaching insert. |
| COOLING: | Water cooled field coils, thermostatically controlled, with overtemperature protection. Tap water requirements: 1 GPM (80°F max.) Armature coil air cooled by remote suction blower. (Blower supplied with shaker, including 10 ft flexible air duct.) |
| TRUNNION: | Full 360° rotation, with locking for operation at any angle. |
| STRAY MAGNETIC FIELD: | Less than 5 gauss at any point 5 inches above table surface. |
| LOAD ATTACHMENT: | Thirteen replaceable inserts (see below) 10-24 threads standard, other sizes available. |
| TOTAL WEIGHT: | 900 pounds, nominal |





**UNHOLTZ-DICKIE CORPORATION**

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**Telephone (203) 288-3358**



Printed in USA

Bulletin S100-76

## TROUBLE SHOOTING THE SYSTEM

If the system is not operating correctly, and the difficulty is not apparent, some of the following checks should be made.

1. Check all the fuses, particularly in the power amplifier.

2. To eliminate some of the possible sources of confusion, the specimen and fixture should be removed from the shaker.

3. Next a check of the system should be made on manual control, with the Automatic Controller in the compressor "off" position. Then repeat the operation of the system to see if the malfunction still exists.

4. Connect an oscilloscope to the system with the following test conditions set up:

   a. Manual operation, free table with no load on shaker. (Compressor Off)
   b. Frequency set to 200 cps.
   c. Field current set to rated 36 amps D.C.
   d. Driver current set to test level 20 amps A.C.(I Collector)
   e. The acceleration "g" level should read 38 "g" using the shaker internal accelerometer.
   f. Check the output waveform with the oscilloscope and note whether or not distorted at the following points: There should be a clean sine wave at all points.

      I. Acceleration signal from Charge Amplifier.
      II. Amplifier output jack on console.
      III. Input signal to amplifier from oscillator. To obtain this it may be necessary to use a BNC Tee connector inside the console or amplifier at the input.
      IV. This check is usually sufficient to isolate the part of the system causing trouble. Sometimes it is necessary to use an ungrounded power line plug on the scope to eliminate ground loops.
      V. Check to see if accelerometer is electrically isolated from shaker. (This may not be required with Model D22 Charge Amplifiers.)

   g. If the system operates correctly with the Automatic Controller in the Compressor "Off", then the trouble must be in the servo section of the Automatic Compressor.

   h. Many times if there is an electrical malfunction, it will cause the shaker to rattle or sound like it is falling apart. These sounds are due to the shaker table trying to follow an erratic electrical input. Before assuming from the sounds that the shaker has fallen apart, the check above listed f-II should be performed. If the amplifier output is badly distorted, then the fault is probably electrical, and not mechanical.

## TROUBLE SHOOTING THE SYSTEM

4. i. If the signal in check f-I above is erratic, a second accelerometer should be mounted on top of the shaker, and a new cable connected into the Charge Amplifier. Then repeat check f-I. One of the most frequent causes of trouble is the accelerometer cables, which are quite fragile.

   j. If the signal in check f-III above is erratic, another oscillator can be connected to the system. An ordinary manually operated oscillator such as the HP200CD can be connected directly to the system power amplifier preamp input.

   k. Ground loops and 60 cycle pickup can sometimes be cleared up by ungrounding all accelerometers mounted on specimens or fixtures. Also any instruments attached to the system may require the use of ungrounded or "cheater" power line plugs.

   l. If the shaker field blows fuses or if the "g" level is well below the level given in check (e) above, then disconnect the shaker power cable and check at the shaker for a resistance to ground on the shaker field coils. Use a VOM for this check.

   m. If you call the factory for additional assistance, it is most helpful if some of the above checks have been performed and values recorded where applicable.

To assist in describing the system operation, the following diagrams are included:

| Title | Dwg. No. | Chg. |
|---|---|---|
| Control Schematic Wiring, System TA250-102 | C15771B | B |
| Signal Schematic, Model TA250A Power Amplifier | D14052M | M |
| | | |
| Customer Information, ~~System~~ Utilities & Cables | B15769A | A |
| Instrument Interconnection | A15828A | A |
| | B13862 | NC |
| Oscillator Schematic OSP-4 | D13846 | NC |
| - Automatic Control Schematic | - | - |
| Schematic Sine/Random Selector Panel, Random Gain | A15830 | NC |
| Shaker Ass'y., Model 102 | B16006 | NC |
| Shaker Ass'y., Model 102 | B16007 | NC |
| Cable & Hose Lengths | A17722A | A |
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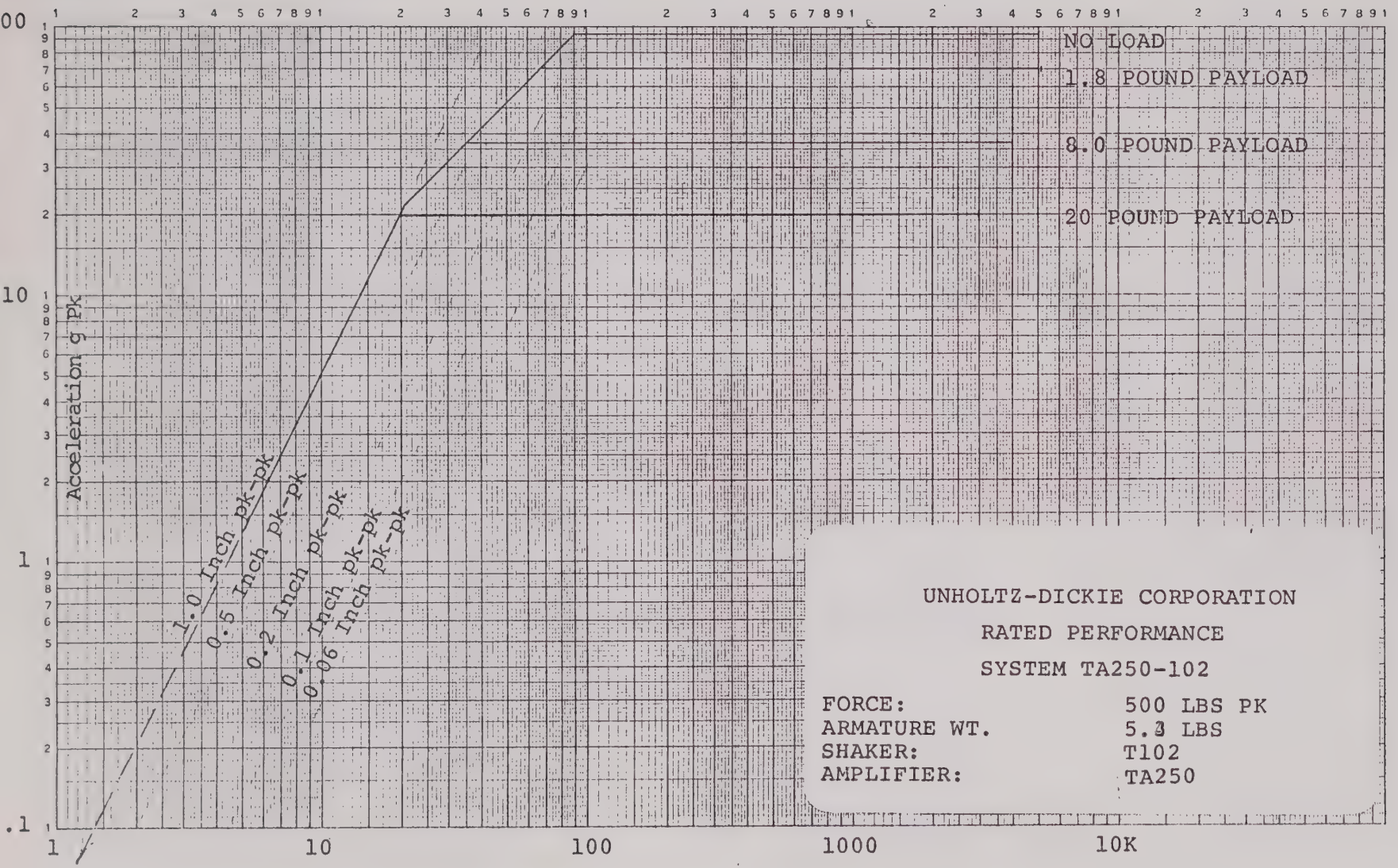
REUFFEL & ESSER CO.




Q-402B

KEUFFEL & ESSER CO. MADE IN U.S.A.

46 5490

ACCELEROMETER MODEL 1060

SERIAL NO. 1849

UNHOLTZ-DICKIE CORP.
BARNES INDUSTRIAL PARK NORTH, 6 BROOKSIDE DR.
WALLINGFORD, CT. 06492 / TEL. (203) 265-0929

# ACCELEROMETER CALIBRATION CERTIFICATE

1. CHARGE SENSITIVITY - Q = 10.05 PC/G AT 100 -Z
2. VOLTAGE SENSITIVITY MEASURED WITH 299 ± 10 PF LOAD CAPACITANCE - $S_L$ = 290 MV/G AT 100 Hz
3. ACCELEROMETER CAPACITANCE $C_A$ = 3156 PF AT 100 Hz
4. TRANSVERSE SENSITIVITY, MAXIMUM 1.1 %
5. CHARGE SENSITIVITY VS FREQUENCY -

+20
PER CENT
+10
0
-10

10 100 FREQUENCY-Hz. 1k 10k

THIS CERTIFIES THAT THE ABOVE CALIBRATION DATA IS TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS LABORATORY NO. 139/223243 AND THAT THE ACCELEROMETER MEETS THE PUBLISHED SPECIFICATIONS.

CERTIFIED A. Brightman
DATE 9-3-82

K&E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 5490

ACCELEROMETER
MODEL 10B10
SERIAL NO. 1850

UNHOLTZ-DICKIE CORP.
BARNES INDUSTRIAL PARK NORTH, 5 BROOKSIDE DR.
WALLINGFORD, CT. 06492 / TEL. (203) 265-3929

# ACCELEROMETER CALIBRATION CERTIFICATE

1. CHARGE SENSITIVITY - Q = 10.0 PC/G AT 100 HZ
2. VOLTAGE SENSITIVITY MEASURED WITH 299 ± 10 PF LOAD CAPACITANCE -
   $S_L$ = 2.91 MV/G AT 100 Hz
3. ACCELEROMETER CAPACITANCE $C_A$ = 9127 PF AT 100 Hz
4. TRANSVERSE SENSITIVITY, MAXIMUM 0.4 %
5. CHARGE SENSITIVITY VS FREQUENCY -

+20
PER CEN
+10
0
-10

10 100 FREQUENCY-Hz 1k 10k

THIS CERTIFIES THAT THE ABOVE CALIBRATION DATA IS TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS LABORATORY NO. 739/233243 AND THAT THE ACCELEROMETER MEETS THE PUBLISHED SPECIFICATIONS.

CERTIFIED A. Brightman
DATE 9-3-82

UNHOLTZ-DICKIE CORPORATION

INTERNAL PRICE SHEET

## ACCELEROMETER CALIBRATIONS

1. STANDARD FREQUENCY RESPONSE CALIBRATION - (supplied with each new accelerometer)

   *Frequency Range -

   - lower frequency limit to 10 Hz
   - upper frequency limit to 10,000 Hz

   *Calibration data supplied as continuously plotted curve of percent deviation vs frequency

   *Calibration level - 2 "g" from 10 Hz to 10,000 Hz standard

   *Capacitance where applicable

   *NBS Traceability Certification

   *COST -

   | | |
   |---|---|
   | 1 - 4 | at $121.00 each |
   | 5 - 9 | at $ 97.00 each |
   | 10 -24 | at $ 85.00 each |
   | 25 UP | at $ 80.00 each |

2. CALIBRATE ONE ACCELEROMETER WITH ITS CHARGE AMPLIFIER OR SIGNAL CONDITIONER TOGETHER----------$250.00

NOTES: (1) We do not limit calibrations to accelerometers manufactured by Unholtz-Dickie.

(2) We will not subject any transducer to environmental extremes beyond the manufacturer's published limits without a written disclaimer of responsibility for any resulting damage.

(3) It is desirable that when a transducer is submitted for calibration that the signal conditioning equipment to be used with the transducer also be submitted to be used during the calibration.

(4) Calibration and/or repair of signal conditioning equipment will be quoted as an extra cost item and that only for equipment manufactured by Unholtz-Dickie. Under no conditions will repairs be performed on equipment manufactured by companies other than Unholtz-Dickie.

(5) Accelerometer calibrations limited to those which are cementable or which have 10-32 threaded mounting holes.

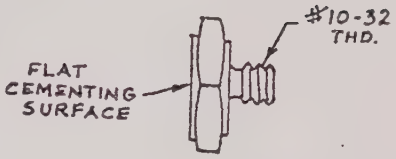
Karl Unholtz

KARL UNHOLTZ

1-1-82

# MOUNTING SMALL ACCELEROMETERS WITH ADHESIVE USING ADAPTER P/N 755074

1. Adapter P/N 755074 provides a flat surface on one side for adhesive mounting and a #10-32 stud on the opposite side for mounting in a #10-32 tapped hole. Small accelerometers, typically less than 50 gm, may be mounted with this adapter.




P/N 755074 ADAPTER

2. We recommend attaching adapter P/N 755074 to the spot chosen for the accelerometer mounting location when it is not desirable or possible to drill and tap a #10-32 hole for stud mounting. In this case the accelerometer may be mounted to the #10-32 stud on the adapter. It should be noted that direct stud mounting into a tapped hole in a flat surface is the preferred accelerometer mounting method to ensure accurate long term vibration measurements.

3. Thoroughly clean the surface to which the adapter will be cemented. Clean off all paint, scale, rust and loose material with a wire brush or sandpaper. It is best to clean down to bare metal. Then wipe the surface clean with a degreasing solvent (e.g. acetone).

4. We recommend the use of either Loctite Super-Bonder 430 Adhesive or Hardman Extra Fast Setting Epoxy for attaching the adapter.

5. Super Bonder is a cyanoacrylate adhesive similar to Eastman 910 adhesive. This adhesive works best between clean flat surfaces whose surface finish is not rougher than about 150 microinches rms. To use this adhesive, apply one drop of Super Bonder to the adapter surface (enough to thinly cover the surface) and press the adapter surface to the prepared mounting spot for ten seconds. The adapter will be ready for use after 15 minutes.

6. Hardman Extra Fast Setting Epoxy is intended for use on non-flat or rough surfaces, and on surfaces where it is difficult to remove all rust or scale. To use the Hardman Epoxy, first mix the two components in the package thoroughly. Then apply epoxy generously to the adapter surface. Press the adapter surface onto the prepared mounting surface for 3-5 minutes. In this time the epoxy will set up sufficiently to hold the adapter in place. In one hour the epoxy will attain about 1/3 of its final strength, and in about 24 hours the bond will be at full strength.

7. To mount the accelerometer onto the adapter, first apply a small drop of machine oil or light grease to the accelerometer mounting surface. Be sure both adapter and accelerometer mounting surfaces are free from dirt. Thread the accelerometer onto the stud and torque to 15-30 inch-pounds. These mounting procedures will help to ensure good dynamic response to 10 kHz.

UDCO

# ACCELEROMETER

## Operating and Instruction

## MANUAL

UM-78

# I. Introduction

## A. General Description

An accelerometer is a transducer which produces an electrical signal proportional to the level of acceleration to which it is subjected. All single-axis accelerometers manufactured by U-D sense the component of acceleration which is perpendicular to the mounting surface of the transducer.

## B. Accelerometer Design Types

### 1. General

Piezoelectric accelerometers manufactured by U-D contain a piezoceramic sensing element attached between the mounting surface of the accelerometer and an inertial mass. The piezoceramic material has the property of producing an electrical signal proportional to its mechanical deformation, within the elastic limits of the material. This deformation is caused by the inertial force of the mass which is attached to the ceramic. This mass tends to remain at its existing level of motion when a changing acceleration is applied to the mounting surface of the accelerometer and thus a net instantaneous force appears across the crystal.

### 2. Shear Type Construction

The cross section of a shear mode accelerometer is shown in Fig. 1 (a). In this shear type design the piezoceramic sensing element is manufactured in the form of a cylinder, and the inertial weight is in the form of a ring attached to the outer cylindrical surface. The inertial force displaces the outer cylindrical surface with respect to the inner cylindrical surface. Examples of U-D shear mode accelerometers are Models 2E5, 2D21, 5D21-8, 10DQ21, and 75D21.

### 3. Compression Type Accelerometers

The cross-section of a compression mode accelerometer

is shown in Fig. 1 (b).

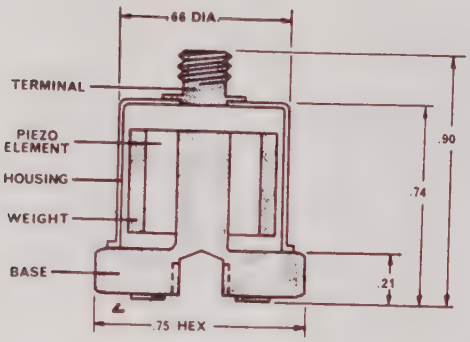



Fig. 1(a)

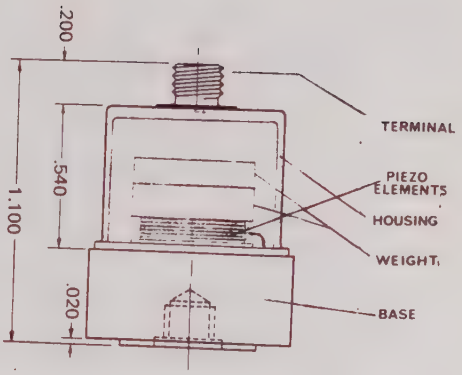



Fig. 1(b)

In this type of design the piezoceramic material is made in form of thin discs which are stacked with the inertial mass on top of the stack. Under acceleration the inertial force compresses or decompresses the stack of discs and produces an electrical signal. Examples of U-D compression mode accelerometers are Models 10B10, 10B10T, and 8B6.

4. Low Output Impedance Accelerometers

Piezoelectric accelerometers are self-generating transducers - i.e. they require no external power supply connections. Also, they have very high output impedances which makes the accelerometer output susceptible to noise signals generated in the cable. Cable noise may be produced by excessive cable motion or ground loops, and is especially noticeable when long lengths of cable are necessary. Noise may be minimized by the use of low noise cable (expensive) and proper control of electrical grounding connections and cable vibrations.

U-D Accelerometers Models 100-PA, 1000-PA, 8803 and 75D21PA have overcome these difficulties by including in the case of the accelerometer an internal electronic circuit which produces a low impedance signal at the accelerometer output terminals. Long lengths of relatively inexpensive cable may be driven by these signals with little or no noise

interference from cable motions. It is necessary to supply power to these accelerometers for the internal electronic circuits, and U-D signal conditioners are available for use with these transducers which automatically supply power at the correct levels. All U-D low impedance accelerometers have a piezoceramic sensing element as their basic sensing mechanism - the Model 8803 is based on the compression design, while the Models 100-PA, 1000PA and 75D21PA are based on the shear mode design.

C. Accelerometer Sensitivity

1. General

The electrical signal generated by the piezoceramic element may be sensed as either an electrical charge or an electrical voltage. Today most new signal conditioners are charge amplifiers, though many voltage amplifiers are still in use in the field.

The sensitivity of an accelerometer is defined as the ratio of the magnitude of the electrical output signal to the magnitude of the mechanical input signal. Output signals may be in millivolts (voltage mode) or in picocoulombs (charge mode), and input is usually expressed in terms of multiples of the acceleration of gravity, or "g"s. Sensitivity is therefore expressed in units of millivolts per "g" (mV/g) or picocoulombs per "g" (pC/g). Since the waveform at calibration is sinusoidal it is important to describe the input sinusoid in the same way (peak, rms, pk-pk) as the output sinusoid. When both sinusoidal signals are described identically, the sensitivity will be expressed in mV/g or pC/g. Otherwise the mixed descriptions must be specified, the most common being mV-rms/g-pk where in this case the magnitude of the input is the zero to-peak amplitude of the acceleration and the magnitude of the output is the rms amplitude of the output voltage. Polarity of the accelerometer output has been standardized by the industry such that an acceleration directed into the mounting surface of the accelerometer will produce a positive charge or voltage on the "high" side of the output connector on the transducer.

It should be noted that if phase information is important the test engineer should check the polarity of the signal conditioner used, as some signal conditioners introduce a net phase reversal into the measurement channel. The voltage amplifier requires that three quantities remain constant for constant channel sensitivity: (1) accelerometer open circuit voltage sensitivity (2) accelerometer capacitance and (3) load capacitance. Also since voltage sensitivity decreases with an increase in cable capacitance for a given accelerometer, this means that the use of long cables with a voltage amplifier will appreciably lower the signal-to-noise ratio of the measurement channel.

The charge amplifier has the advantages that (1) long cable lengths - up to 5000 ft - may be used with no significant reduction in charge sensitivity and (2) one calibration setting - the accelerometer charge sensitivity - is sufficient for each accelerometer regardless of accelerometer capacitance or load capacitance. In fact, when many U-D Model 10B10 or 10B10T accelerometers are used in a large test program, the normalized charge sensitivity of 10.0 pC/g ±2% simplifies greatly the task of keeping track of accelerometer sensitivity at each location and reduces the chance of error during data reduction. Other U-D accelerometers with normalized outputs are the Model 100-PA (100 mV/g ±2%), 1000-PA (1 v/g ±2%) and 8803 (100 mV/g ±2%).

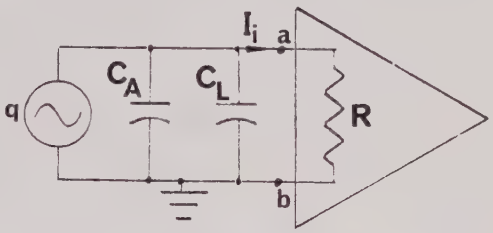
2. Voltage Sensitivity

A voltage amplifier typically has a high resistive input impedance which ranges up to 1000 megohms in typical cases. Vibrating the accelerometer produces a charge proportional to acceleration which appears as a voltage across the accelerometer capacitance $C_A$ and the cable capacitance $C_C$ according to the equation

$$E = \frac{Q}{(C_A + C_C)}$$

This shows the dependence of the input voltage on the circuit capacitance when a voltage amplifier is used. The low

frequency response of the accelerometer-voltage amplifier combination is determined by the time constant $R(C_A + C_C)$ where R is the input resistance to the amplifier. The higher the input resistance, the higher the time constant; therefore the low frequency cutoff is decreased with an increase in R. Fig. 2 shows the simplified charge equivalent circuit of an accelerometer connected to a voltage amplifier. This representation leads to the simplest calculation of voltage sensitivity for any load capacitance. The voltage sensitivity ($S_L$) is the charge sensitivity (Q) in coulombs/g divided by the sum of the accelerometer capacitance, the cable capacitance and the amplifier input capacitance in farads. The sum of the cable and input capacitances is called the load capacitance ($C_L$). Thus:




$I_i \cong 0$ because of very large input resistance R

**Fig. 2**

$$S_L = \frac{Q \times 1000}{C_{ACCEL} + C_{CABLE} + C_{INPUT}} = \frac{1000\ Q}{C_A + C_L} \quad \frac{mV}{g} \quad (1)$$

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Example: Given a U-D Model 75D21 accelerometer with a charge sensitivity of 79.6 pC/g and an internal capacitance of 1056 pF, determine the voltage sensitivity when using a 50 ft cable with 1503 pF and amplifier input capacitance of 10 pF.

Answer:

$$S_L = \frac{1000\ Q}{C_A + C_L} = \frac{(1000)(79.6 \times 10^{-12})}{(1056 + 1503 + 10) \times 10^{-12}}$$

$$S_L = 31.0\ mV/g$$

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If the accelerometer cable is changed then the voltage sensitivity $S_L$ must be recalculated to reflect that change. If $C_L$ is the new load capacitance and $S_L$ is the new voltage sensitivity, then

$$S_L{}^1 = S_L \frac{C_A + C_L}{C_A + C_L} \qquad (2)$$

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

Example: What will the voltage sensitivity be for the U-D Model 75D21 in the previous example with a new 175 ft cable with 5340 pF capacitance?

Answer: $S_L{}^1 = 31.0 \frac{(1056 + 1503 + 10)}{(1056 + 5340 + 10)}$

$S_L{}^1 = 12.4$ mV/g

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

3. Charge Sensitivity

The charge sensitivity of an accelerometer is independent of cable capacitances or other load capacitances within reasonable limits. To take advantage of this fact a charge amplifier must be used as the signal conditioning amplifier. It is necessary simply to set the correct sensitivity into the charge amplifier and proceed to test.

The charge amplifier is a high gain amplifier with a relatively large capacitor in the feedback path (see Fig. 3). The amplification factor A is very large and negative and the input impedance to A is very large. We consider this amplifier with a charge - equivalent source (see Fig. 4).

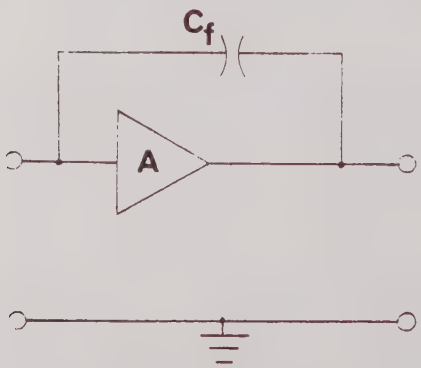


Fig. 3

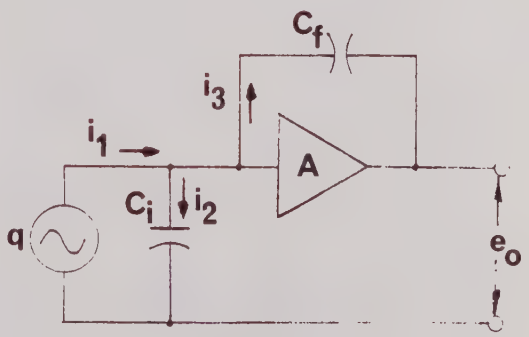


Fig. 4

$$i_1 = i_2 + i_3 \quad \text{(since input impedance to A is very large)}$$

$$Q = C_i e + C_f (e_i - e_o)$$

$$Q = \frac{C_i\, e_o}{A} + \frac{C_f\, e_o}{A} - C_f\, e_o \quad (\text{since } e_o = A e_i)$$

$$\frac{Q}{e_o} = \frac{C_i + C_f}{A} - C_f$$

Since A is very large, $\frac{C_i + C_f}{A} \ll C_f$ and thus $\frac{Q}{e_o} = - C_f$,

or
$$e_o = - \frac{Q}{C_f} \qquad (3)$$

In other words, the output voltage depends only on the charge input and not on the value of $C_i$.

Low frequency response of the measurement channel is a function of the charge amplifier only. It does not depend on the accelerometer capacitance or the cable capacitance.

If the assumption that $\frac{C_i + C_f}{A} \ll C_f$ is not made, it may be shown that for reasonable circuit values (A = 10,000, $C_f$ = 1000 pF) $C_i$ may vary from small values up to 99,000 pF with a 1% maximum change in output. This corresponds to approximately 3300 ft of low noise coaxial cable, (about 1 km).

## II. Accelerometer Characteristics

### A. General

When considering the accuracy of measurements made with an accelerometer, several factors should be taken into account. Variations in sensitivity within specified limits may occur with changes in frequency, temperature and vibration amplitude. In addition, spurious transducer output signals due to transverse sensitivity, thermal shock sensitivity, base strain sensitivity and cable whip sensitivity may be present to detract from accuracy. Fortunately, in a modern well designed accelerometer these effects can be minimized and are negligible.

### B. High Frequency Response

The high frequency response of a piezoelectric accelerometer is determined by its mechanical spring - mass characteristics. The accelerometer response may be approximated by the response of a very lightly damped single degree of freedom system.

A typical accelerometer exhibits negligible sensitivity variation with frequency from a few Hz up to several thousand Hz. At the upper end of this frequency band the sensitivity of the accelerometer begins to increase. Fig. 5 shows this rising response on a normalized frequency basis for an undamped resonant system. At approximately 1/5 of the resonant frequency (0.2 on the normalized scale) the response is up about 4%, and the response is up about 50% at approximately 57% of the resonant frequency. In most cases the useful frequency range is set between those frequencies at which the accelerometer sensitivity deviates more than 5% from the reference sensitivity. A continuous calibration curve drawn for each accelerometer is the clearest and most graphic method of determining accelerometer response from as low as 2 Hz up to 10,000 Hz. The U-D Model 351 Automatic Recording Vibration Calibration System produces such a curve quickly and easily.

A larger useful frequency range may usually be obtained by using a smaller accelerometer. A tradeoff with lower accelerometer sensitivity is usually required in this case.

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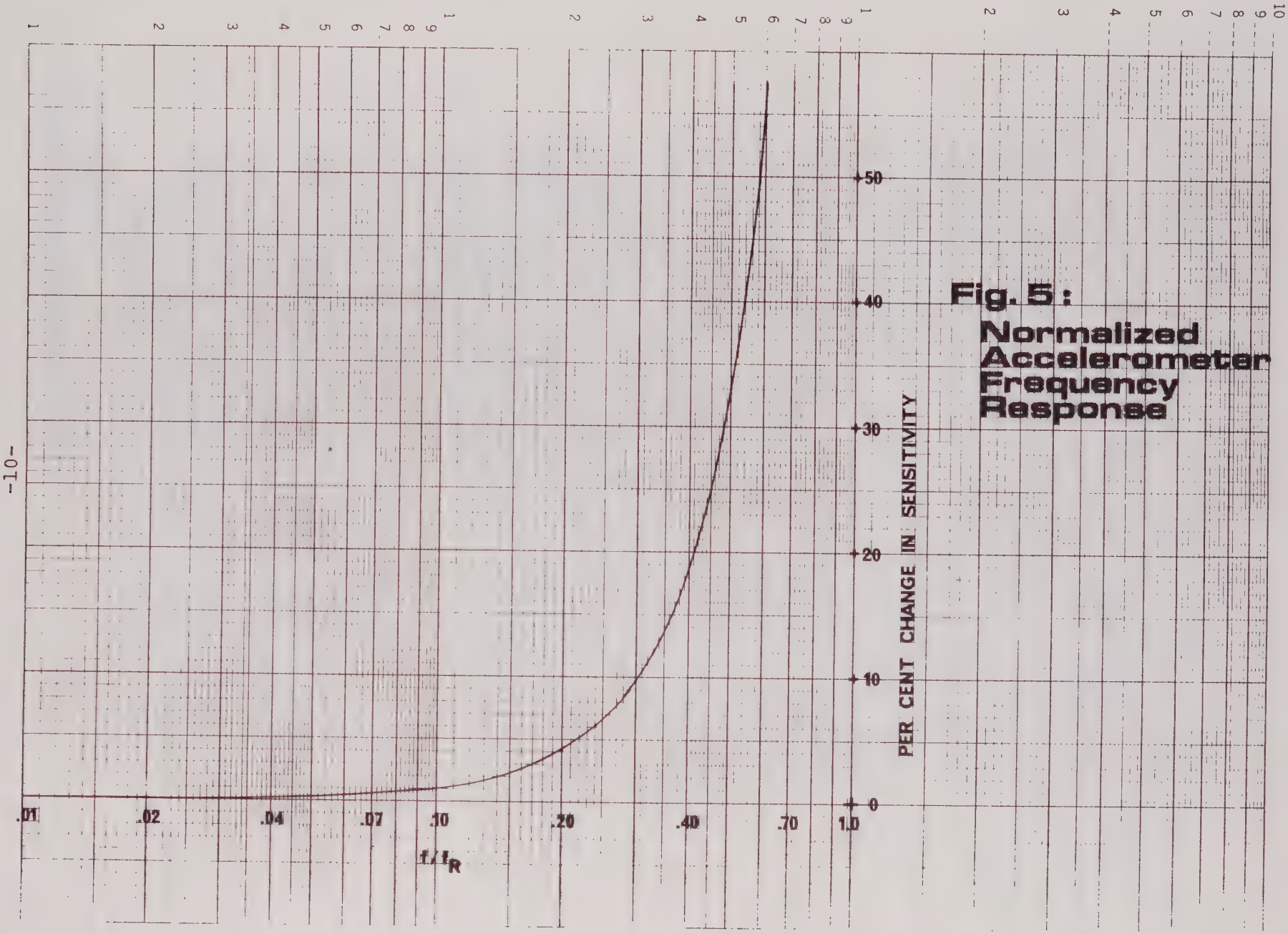


**Fig. 5: Normalized Accelerometer Frequency Response**

Another way of increasing the useful frequency range of the accelerometer is to provide a compensating filter in the signal conditioning equipment. Such a filter will have decreasing gain with increasing frequency and will be designed to just offset the increase in accelerometer sensitivity with increasing frequency. This method does not require accepting a lower accelerometer sensitivity to obtain greater useful frequency range, but it does not raise the actual accelerometer resonant frequency.

Measurement of accelerometer resonant frequency does not guarantee an accurate determination of useful accelerometer frequency range. Resonant frequency is usually measured in one of two different ways: the "free" resonant frequency is that of the unmounted accelerometer, and the "mounted" resonant frequency is that measured when the accelerometer is mounted on a massive fixture whose mass may approach "infinite" with respect to the mass of the accelerometer itself. The "free" resonance is usually 2-3 times higher than the "mounted" resonance. Obviously the "mounted" resonance most closely approximates the actual conditions of use of the accelerometer. Even so, direct measurement of the accelerometer sensitivity over the frequency range of interest in the actual test, preferably a continuous measurement, is the only way to accurately describe the small continuous variations and possible resonances due to many different causes (e.g. cable connectors) which may affect test measurements.

C. Low Frequency Response

1. Voltage Amplifier Operation

With a voltage amplifier the low frequency response will be determined by either the amplifier low frequency response or the time constant of the combined RC circuit where R is the amplifier input resistance and C is the sum of the accelerometer and cable capacitances. Fig. 6 is a normalized curve of this low frequency dropoff characteristic. In most cases the lower frequency limit of usefulness is taken to be that frequency at which the combined accelerometer--signal conditioner response is down 5%.

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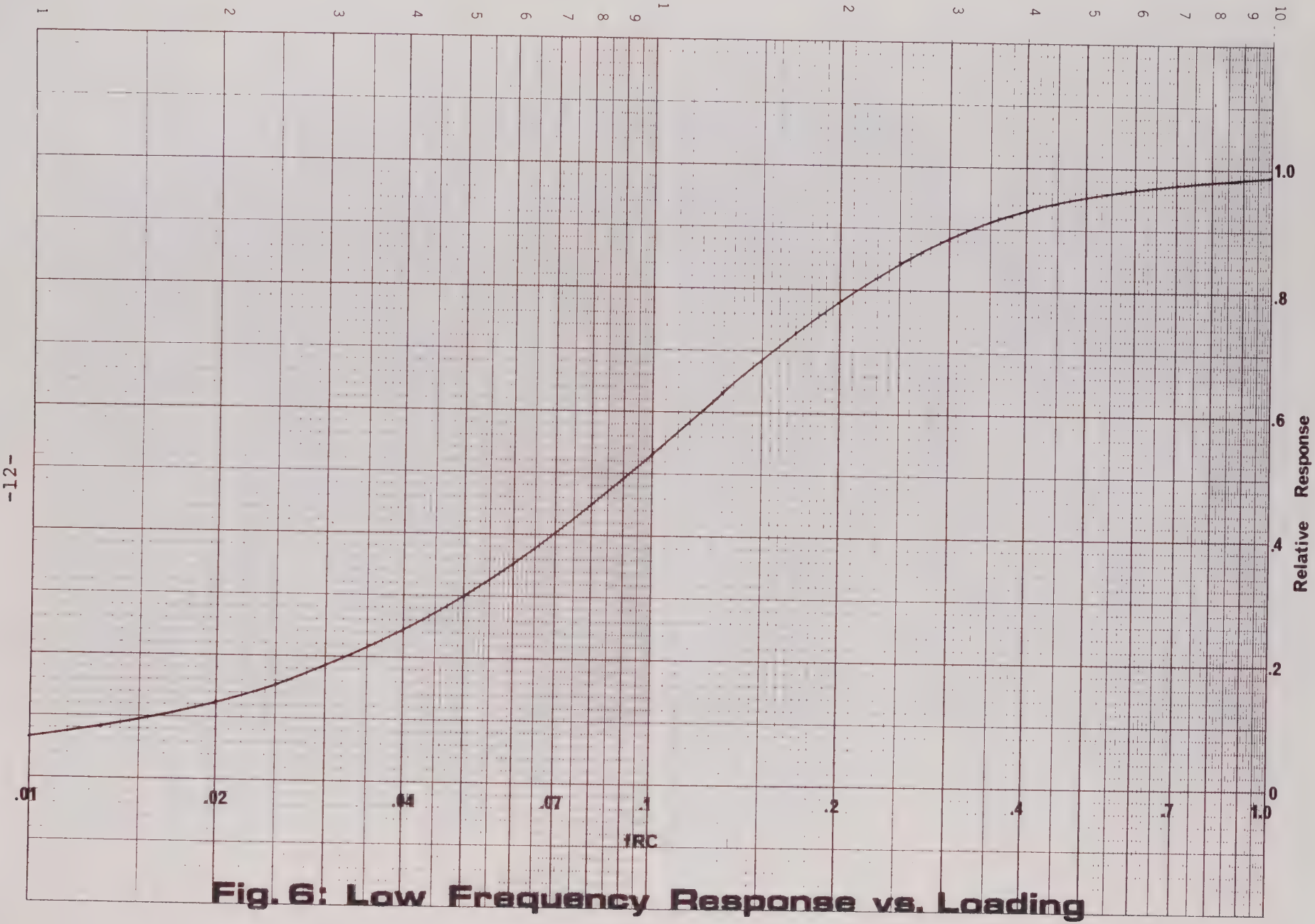


**Fig. 6: Low Frequency Response vs. Loading**

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Example: A Model 5D21-8 accelerometer with 1573 pF capacitance is connected with a 305 pF cable to a voltage amplifier having an input resistance of 1000 megohms. Find the frequency at which the sensitivity is down 5%. Answer = From Fig. 6 the 5% point (relative response = .95) corresponds to fRC = 0.48. Thus

$$C = 1573 + 305 \text{ pF} = 1878 \text{ pF}$$

$$f = \frac{0.48}{10^3 \times 10^6 \times 1878 \times 10^{-12}} = 0.26 \text{ Hz}$$

Since the amplifier frequency response is probably not this low, it alone would dominate the accelerometer response and determine the low frequency limit.

---

2. Charge Amplifier Operation

When the accelerometer is used with a charge amplifier, the low frequency response is that of the charge amplifier alone. As is the case with charge sensitivity, the low frequency response when using a charge amplifier is not affected by accelerometer or cable capacitance.

D. Sensitivity Variations with Temperature

The major determinant of the manner in which accelerometer sensitivity varies with changes in ambient temperature conditions is the piezoceramic material of which the accelerometer is made. U-D accelerometers use two basic types of piezoceramic materials, lead zirconate-titanate (PbZrTi) compositions and bismuth-strontium-titanate (BiSrTi) compositions. The absolute upper temperature limit for any piezoelectric accelerometer is the curie temperature (Tc) at which the piezoceramic material will irreversibly lose its polarization and the accelerometer will have no output. At temperatures of approximately 0.5Tc and below we find reversible changes in accelerometer charge sensitivity, capacitance and resistance with changes in temperature. Typical variations of these parameters with temperature are shown in Figs. 7(a), 7(b), 7(c), and 7(d).

Voltage sensitivity in general will change with temperature in a different manner than charge sensitivity. Variation of resistance and capacitance with temperature will also change low

frequency response into a voltage amplifier. If the accelerometer resistance falls low enough, it may shunt the voltage amplifier input resistance. In addition, a change in load capacitance changes the temperature response. Fig. 8 represents different voltage sensitivity variations for varying load capacitances for a typical accelerometer.

——— Pb(Zr,Ti) ——— (Bi,Sr)Ti

Fig. 7(a): Charge Sensitivity vs. Temp.

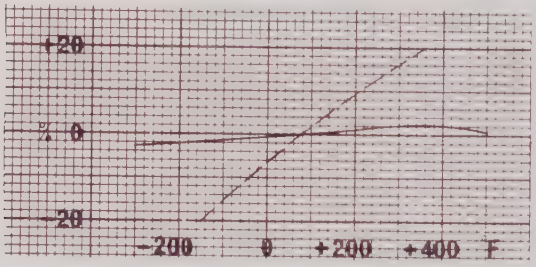



Fig. 7(b): Voltage Sensitivity vs. Temp.

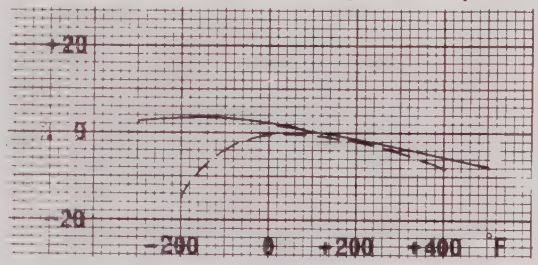



Fig. 7(c): Capacitance vs. Temp.

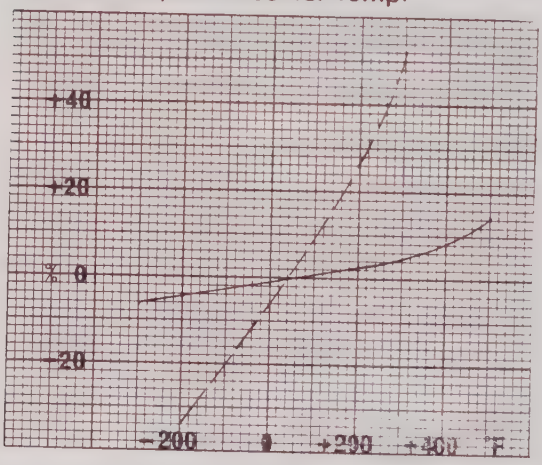



Fig. 7(d): Resistance vs. Temp.

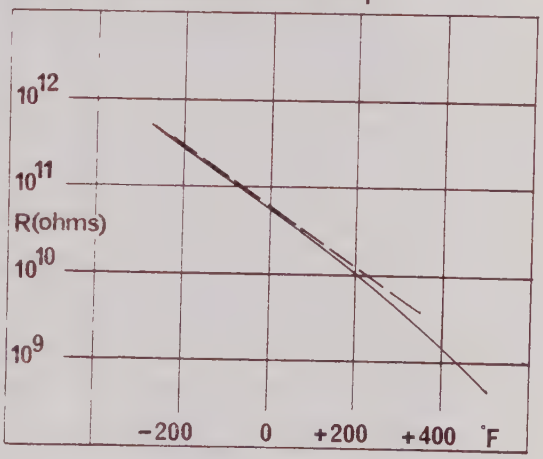
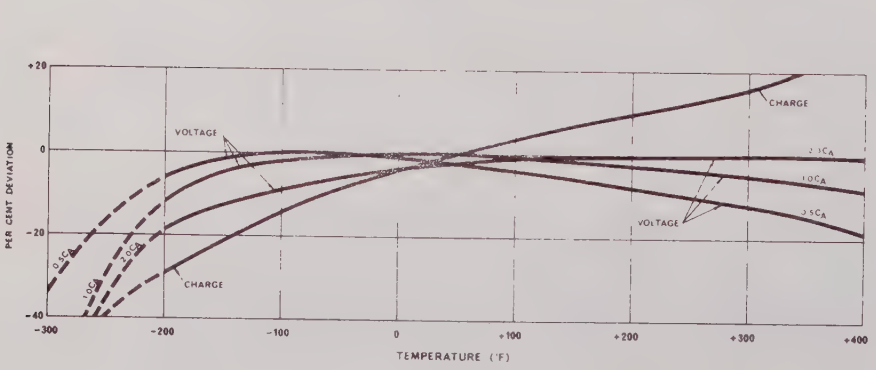



**Fig. 7: Typical Variations of Accelerometer Properties with Temperature**




NOTE: 1. Variation of sensitivity with temperature is shown at 100 Hz
2. Voltage sensitivity variations are shown for load capacitances which are multiples of accelerometer capacitance ($C_A$). Thus voltage temperature response may be optimized for any temperature range by proper choice of load capacitance.

**Fig. 8: Typical Load Capacitance Effects on Temperature Variations**

E. Accelerometer Linearity - Sensitivity Variations with Vibration Amplitude

Most piezoelectric accelerometers are extremely linear over a wide range of acceleration amplitudes. A dynamic range of 100 dB with less than 1% sensitivity error is quite common.

F. Temperature Cycling

Partial depolarization and reduction of sensitivity due to temperature cycling may be avoided by always loading the accelerometers while cycling. Either shorting out the accelerometer output terminal or attaching the accelerometer to a signal conditioner will be sufficient to remove excess voltage from across the crystals. The depolarization effect is due to voltage potential buildup across the piezoceramic sensing element due to thermally induced stresses in the accelerometer structure.

G. Transverse Sensitivity

An output from an accelerometer when the accelerometer is driven at right angles to its sensitive axis indicates that the accelerometer has a transverse sensitivity. The transverse sensitivity has a maximum value in some direction of rotation about the major axis, and a minimum at a position 90° away from the maximum. A plot of transverse sensitivity of a typical accelerometer is shown in Fig. 9 as a function of angle of rotation about the sensitive axis.

The transverse sensitivity is measured at a single frequency, usually below 200 Hz. This frequency is chosen to minimize transverse motion of the fixture used. The assumption is made that the transverse sensitivity remains essentially unchanged over the frequency range up to at least a few thousand Hertz. Actual measurement of this frequency response of transverse sensitivity leads to many uncertainties. However, many measurements of shaker transverse motion up to 10,000 Hz with many different type accelerometers lead

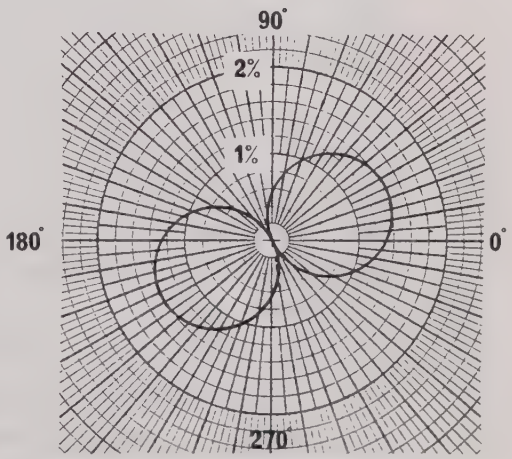



Fig. 9: Transverse Sensitivity vs. Rotation Angle

us to believe that there are no major variations in accelerometer transverse sensitivity with frequency up to at least 10,000 Hz.

H. Phase Shift

It is particularly important when measuring complex waveforms that the phase shift between one frequency component of the waveform and any other frequency component be zero. If the accelerometer and signal conditioner introduce a frequency-varying time delay in the frequency range of interest, the output of the signal conditioner will be a distortion of the mechanical input. Very few vibrations in the real world are pure single-frequency sinusoids, and therefore to reproduce these signals accurately it is important to maintain the original time relationship of any one frequency component with all the others.

Piezoelectric accelerometers are spring-mass systems with very low damping, and therefore maintain zero phase shift up to very near their resonant frequency, and therefore through their useful frequency range.

K. Case Strain and Cable Whip Sensitivity

When the piezoelectric sensing element and inertial mass are not sufficiently isolated from the accelerometer structure, sizeable outputs can result from causes unrelated to axial vibration. In every case, these unwanted outputs are caused by stresses in the outer structure which strain the sensing element, either through the base or through the inertial mass. Fig. 10 shows a typical poorly designed accelerometer. The case provides the spring loading of the mass on the sensing element. If the case is subjected to a mechanical or thermal shock, it will be strained and will change dimensions slightly. This will change the loading on the sensing element and an unwanted output will result.

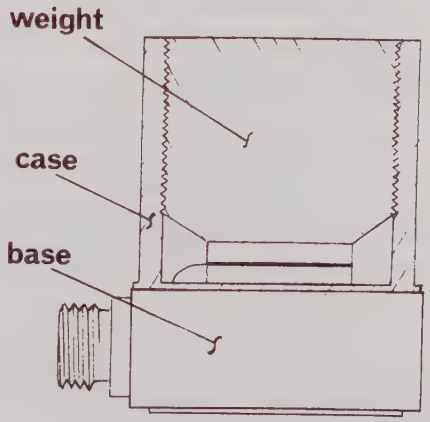



**Fig. 10: Poor Design - Case Sensitive**

One of the simplest methods for checking an accelerometer for case sensitivity is to apply a slight thermal shock to the case by switching on an incandescent light bulb placed a few feet from the accelerometer. When the light bulb is turned on, the output may be observed on an oscilloscope, using the DC input. In a well-designed accelerometer the output from such a thermal shock is negligible. In some poorly isolated accelerometers, even the temperature changes resulting from drafts in the room can result in outputs of several "g's".

Cable whip sensitivity results from forces being transmitted to the sensing element through motion of the connecting cable. If the cable connector on the accelerometer has varying forces applied to it, these forces may be transmitted to the case and cause minute strains in the case. Again, with good accelerometer design such strains resulting from cable whipping will not result in a significant output signal. To check an accelerometer for cable whip sensitivity, flex the accelerometer cable close to the connector with accelerometer mounted on a large rigid structure. Then connect the cable to a capacitance approximately equal to the accelerometer capacitance and repeat the test. The accelerometer outputs from each test may be observed on an oscilloscope and the observer may see any significant increase in output with the accelerometer attached to the cable.

L. Base Strain Sensitivity

In some test environments the surface on which the accelerometer is mounted is bending and distorting as well as vibrating. If a significant output results from the strains in the accelerometer base caused by the bending and distorting of the mounting surface, then the accelerometer is said to be base strain sensitive. This sensitivity is expressed in terms of equivalent "g's" per microinch per inch strain on the mounting surface.

Measurement of base strain sensitivity in the laboratory is done by mounting the test accelerometer at the inboard end of a cantilever beam, as in Fig. 11. When the free end of the beam is is vibrated at a known amplitude, a known strain appears on the surface of the beam where the accelerometer is mounted. This strain

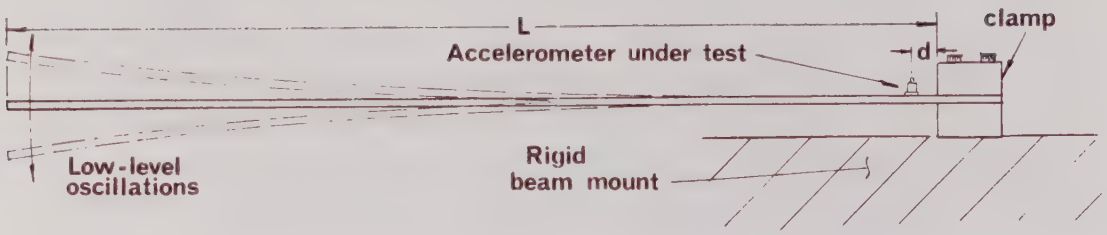



**Fig. 11: Base Strain Sensitivity Test, adapted from ISA Standard RP37.2 para. 6.6**

is transmitted to the base of the accelerometer, and will produce an output if the accelerometer is base strain sensitive. Since the accelerometer is mounted very near the damped end of the beam, and since the frequency of vibration is low (about 5 Hz), acceleration due to vertical motion of the beam at the accelerometer mounting count is negligible. Thus any output from the accelerometer may be considered to be the result of base strain only. This may be checked on the beam by placing the accelerometer on the mounting point without torquing it down and repeating the test.

Base strain sensitivity is inherently very small in the shear mode design accelerometer shown in Fig. 1(a), Part I. The compression design shown in Fig. 1(b), Part I has been made relatively free of base strain problems by special designs which reduce the transmission of strain to the sensing element.

UNHOLTZ-DICKIE CORPORATION

VIBRATION TEST EQUIPMENT

# Model 10B10 and 10B10T

## Piezoelectric Accelerometer

### KEY FEATURES

- **Normalized 10 pC/g charge sensitivity**
- **Temp range -300° F to +500° F**
- **Low base and case strain sensitivity**
- **Flat charge sensitivity vs frequency**
- **Flat charge sensitivity vs temperature**
- **Mounted resonant frequency 30 kHz**

**10B10**

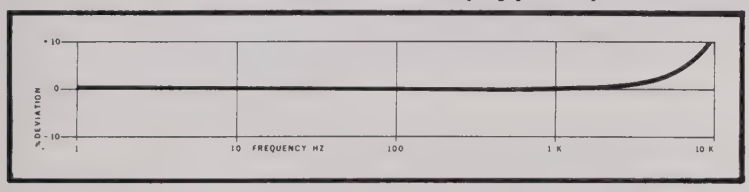
**10B10T**

The **10B10** and **10B10T** Accelerometers are general purpose piezoelectric vibration transducers designed with wide operating temperature range for use in the charge mode. The factory adjusted sensitivity of 10 pC/g is maintained for all units, eliminating the task of matching different transducer sensitivities to companion charge amplifier input settings.

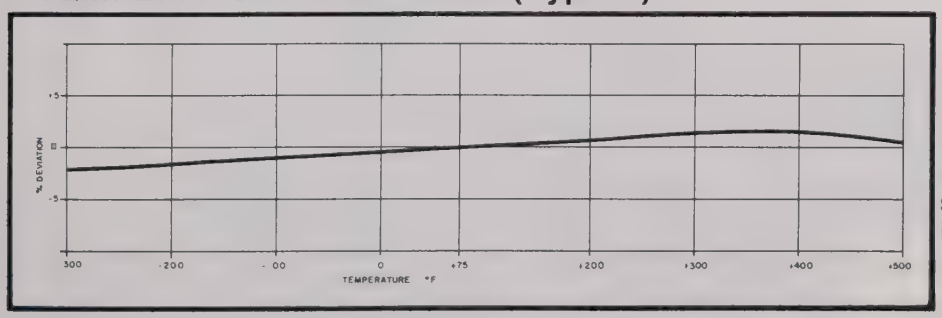
### DYNAMIC PERFORMANCE

| | |
|---|---|
| Charge Sensitivity: | 10.0 pC/g ±2% |
| Open Circuit Voltage Sensitivity: | 3.2 mV/g typical |
| Accelerometer Capacitance: | 3100 pF typical at 100 Hz |
| Mounted Resonant Frequency: | 30,000 Hz typical |
| Transverse Sensitivity: | 3% max at 150 Hz 1% typical |
| Accelerometer Resistance: | 20,000 megohms min at 75° F<br>500 megohms min at 500° F |
| Frequency Response: | (See curve below) |
| Amplitude Linearity: | Within 2% of best straight line (2000 g range) |

### FREQUENCY RESPONSE (Typical)

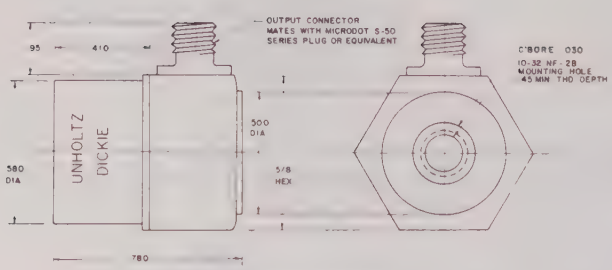



### TEMPERATURE RESPONSE (Typical)

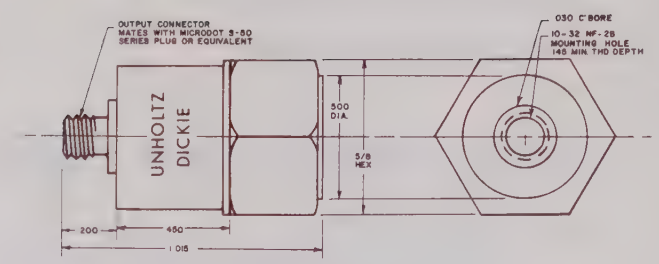


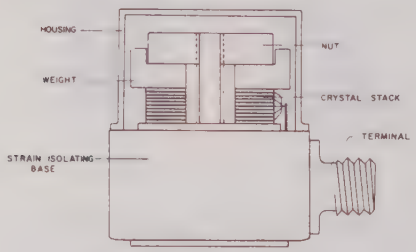

**NOTE:** Variation of charge sensitivity with temperature is shown at 100 Hz.

**10B10**

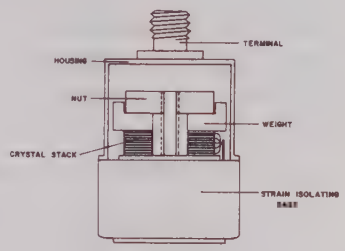



**10B10T**




**Section View**




**Section View**

## SPECIFICATIONS

### MECHANICAL

| | |
|---|---|
| Design Type: | Compression mode, grounded case, strain isolating double base |
| Connector: | 10B10 Side connector<br>10B10T Top connector |
| Piezoelectric Material: | Bismuth strontium titanate |
| Dimensions: | (See dim. dwg. above) |
| Weight: | 1 oz (27 gm) nominal |
| Mounting: | 10-32 internal thread, .145 inch deep |
| Case: | Type 303 stainless steel |
| Accessories Supplied: | 10 ft Microdot low noise cable (3808-10) plus 10-32 x 3/8 inch stud |

### ENVIRONMENTAL

| | |
|---|---|
| Dynamic Range: | 1000 g sinusoidal, 2000 g shock |
| Temperature Range: | (see temp response curve)<br>-300° F to +500° F for ±5% charge sensitivity variation<br>-300° F to +350° F for +0%, -5% voltage sensitivity variation with typical capacitive load |
| Base Strain Sensitivity: | 10B10: Equivalent .005g/microinch/inch strain, typical<br>10B10T: Equivalent .002g/microinch/inch strain, typical |
| Seal: | True hermetic seal, grade A, with welded and glass-to-metal bonds |

Calibration of each accelerometer is accomplished by comparison to a National Bureau of Standards traceable reference. Using a U-D Model 351 Calibration System, a continuous calibration curve is plotted from 10 to 10,000 Hz, showing percent deviation of charge sensitivity as compared to the sensitivity measured at the 100 Hz reference frequency.

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SHORT FORM CATALOG

# VIBRATION TEST EQUIPMENT

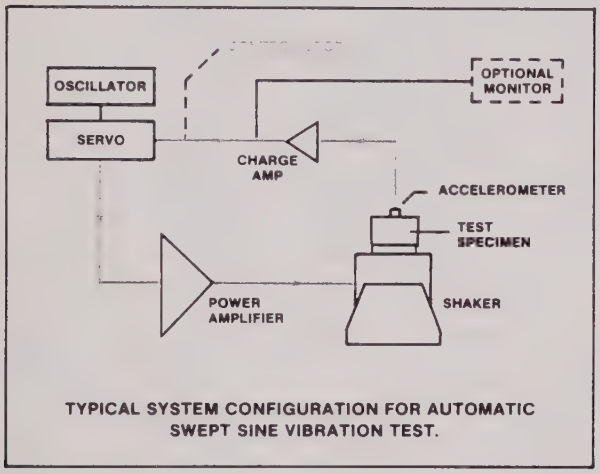
UNHOLTZ-DICKIE CORPORATION

# INTRODUCTION

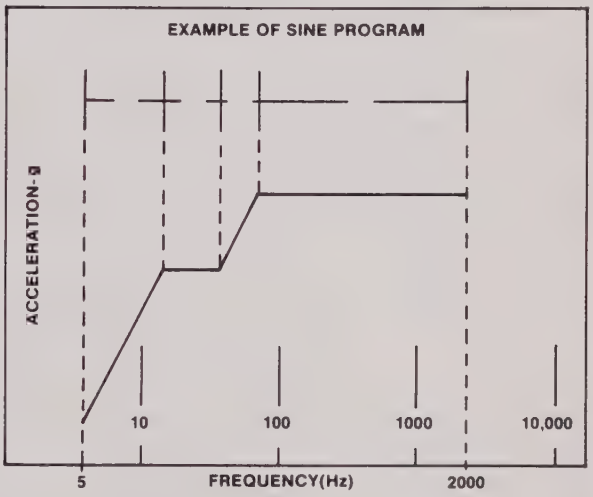
Vibration testing has been a major tool used in the development of military and space hardware for over 25 years. Today, the benefits of vibration testing are being applied in a variety of commercial and consumer product areas as well. This trend parallels an increasing number of federal regulations which require more comprehensive testing to assure product reliability and safety.

Vibration testing can genuinely benefit the manufacturer. By simulating environmental vibration levels during actual product development, the engineer can verify that a design is suitable for its application. This type of testing establishes performance and reliability prior to release of a design for production. Such an approach can save money by minimizing the probability of major redesign work, and even legal liabilities which may result from an inadequate product design. In addition, quality control procedures can be enhanced by using vibration testing as a tool to monitor the consistency of production methods and materials.

Electrodynamic vibration test systems are used to satisfy a wide variety of test requirements. A typical test configuration for swept sine vibration testing is illustrated below (left). This arrangement provides for automatic frequency cycling at preselected vibration levels under servo control. A typical four-level sine test "program" is shown at the right.




TYPICAL SYSTEM CONFIGURATION FOR AUTOMATIC SWEPT SINE VIBRATION TEST.




# CONTENTS


VIBRATION TEST SYSTEMS ..... 3
SHAKERS ..... 4
INDUCT-A-RING ARMATURES ..... 6
PERMALINE SLIP TABLES ..... 7
SOLID STATE POWER AMPLIFIERS ..... 8
SPECIMEN PROTECTION ACCESSORIES ..... 9
REPLACEMENT SOLID STATE POWER AMPLIFIERS ..... 10
CLOSED LOOP WATER COOLING ACCESSORIES ..... 10
MIL-STD-781C PRODUCTS ..... 11
RANDOM VIBRATION CONTROLS ..... 11
MODAL SHAKERS ..... 12
TRANSDUCER CALIBRATION SYSTEMS ..... 12
AUTOMATIC SINE CONTROLS ..... 13
ENGINE TEST CELL MONITORING ..... 13
TRACKING FILTERS ..... 13
CONTROL/MONITORING ACCESSORIES ..... 14
D22 SERIES SIGNAL CONDITIONERS ..... 15
ACCELEROMETERS ..... 16
INDUSTRIAL VIBRATION MONITORS ..... 16

# VIBRATION TEST SYSTEMS

Unholtz-Dickie produces a wide range of vibration test systems to meet both military and commercial testing requirements. System force ratings from 50 to 40,000 pounds force are available. The table below lists these systems with pertinent technical data.

Every U-D system includes a solid state power amplifier and features reliable air cooling of the shaker armature. Systems engineering of each system component assures maximum performance with simplified operation.

| SHAKER MODEL/ SERIES | SYSTEM PERFORMANCE | | | | SHAKER DATA | | | |
|---|---|---|---|---|---|---|---|---|
| | FORCE, lbs. | | STROKE inches DA | MAX. SINE PAYLOAD AT 20g | ARMATURE WEIGHT, lbs. | TABLE DIA., inches | FREE TABLE $f_n$ | SUSPENSION STIFFNESS lbs./inch |
| | SINE pk | RANDOM rms | | | | | | |
| **5PM** | 50 | | 0.5 | 1.8 | 0.7 | 2 | 8,000 | 60 |
| **1**(1) | 50 | | 1 | 1.9 | 0.55 | drive rod | 5,500 | 0 |
| **20** | 120 | 60 | 1 | 3 | 3 | 3.5 | 3,300 | 225 |
| **4**(1) | 150 | | 4 | 5.2 | 2.25 | drive rod | 3,000 | 0 |
| **4C**(1) | 250 | | 4 | 9 | 3.5 | drive rod | 2,400 | 0 |
| **20** | 250 | 125 | 1 | 9.5 | 3 | 3.5 | 3,300 | 225 |
| **20** | 300 | 185 | 1 | 12 | 3 | 3.5 | 3,300 | 225 |
| **T102** | 500 | 300 | 1 | 19.7 | 5.3 | 4.5 | 4,300 | 225 |
| **6**(1) | 1,000 | | 6 | 39 | 11 | drive rod | 1,800 | 0 |
| **200 SERIES** | 1,200 | 600 | 1 | 40 | 20 | 8 | 3,100 | 600 |
| | 1,700 | 850 | 1 | 65 | 20 | 8 | 3,100 | 600 |
| | 3,000 | 2,200 | 1 | 128 | 22 | 8 | 3,100 | 600 |
| | 3,000(2) | | 0.5 | | 31* | 8 | 5,800 | 600 |
| | 4,000 | 3,300 | 1 | 171 | 29 | 8 | 2,700 | 600 |
| **RTS-5 V560** | CONSULT FACTORY (see page 11) | | | | | | | |
| **500 SERIES** | 6,000 | 3,000 | 1 | 264 | 36 | 12 | 2,800 | 1,200 |
| | 6,000 | 4,500 | 1 | 264 | 36 | 12 | 2,800 | 1,200 |
| | 7,000 | 4,000 | 1 | 300 | 50 | 12 | 2,400 | 1,200 |
| | 7,000 | 5,500 | 1 | 300 | 50 | 12 | 2,400 | 1,200 |
| **1000 SERIES** | 8,000 | 4,000 | 1 | 310 | 90 | 16 | 2,300 | 3,000 |
| | 10,000 | 5,000 | 1 | 410 | 90 | 16 | 2,300 | 3,000 |
| | 12,000 | 6,000 | 1 | 510 | 90 | 16 | 2,300 | 3,000 |
| | 11,000 | 7,500 | 0.7(3) | 505 | 95* | 16 | 2,300 | 3,000 |
| | 15,000 | 9,500 | 0.75(3) | 655 | 95* | 16 | 2,300 | 3,000 |
| | 16,000 | 11,500 | 1 | 705 | 95* | 16 | 2,300 | 3,000 |
| | 17,000 | 9,500 | 1 | 755 | 95* | 16 | 2,300 | 3,000 |
| | 17,500 | 14,000 | 1 | 780 | 95* | 16 | 2,300 | 3,000 |
| | 17,500 | 16,000 | 1 | 780 | 95* | 16 | 2,300 | 3,000 |
| | 19,000 | 15,000 | 0.9 (3) | 855 | 95* | 16 | 2,300 | 3,000 |
| | 19,000 | 17,500 | 1 | 855 | 95* | 16 | 2,300 | 3,000 |
| | 24,000 | 20,000 | 1 | 1,105 | 95* | 16 | 2,300 | 3,000 |
| **4000 SERIES** | 28,000 | 20,000 | 0.75 (3) | 1,160 | 240* | 24 | 1,800 | 4,000 |
| | 36,000 | 33,000 | 1 | 1,560 | 240* | 24 | 1,800 | 4,000 |
| | 40,000 | 30,000 | 1 | 1,760 | 240* | 24 | 1,800 | 4,000 |
| | 40,000 | 40,000 | 1 | 1,760 | 240* | 24 | 1,800 | 4,000 |

* Induct-A-Ring (IAR) armature

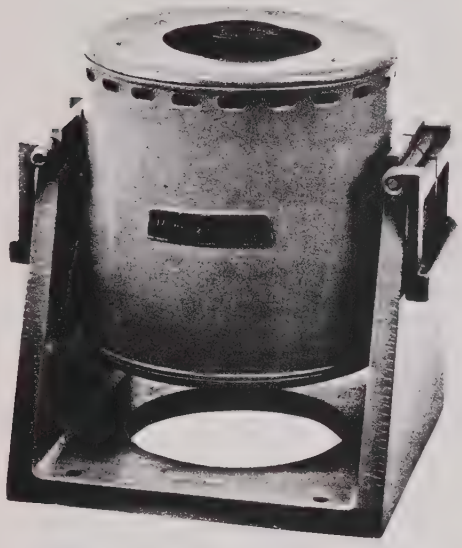
(1) Modal shaker

(2) Special high freq. IAR design

(3) 1 inch stroke with reduced force rating

# SHAKERS

Unholtz-Dickie manufactures a wide variety of general purpose and special application shakers, covering the force range from 50 to 40,000 pounds as illustrated on the following pages.



**Max Output:**
50 lbs pk force
0.5 inch pk-pk stroke

**Cooling:**
Air

**Armature Type:**
Wound Coil

**Body Dia:**
8 - 7/16"

**Max Output:**
300 lbs pk force
1 inch pk-pk stroke

**Cooling:**
Air

**Armature Type:**
Wound Coil

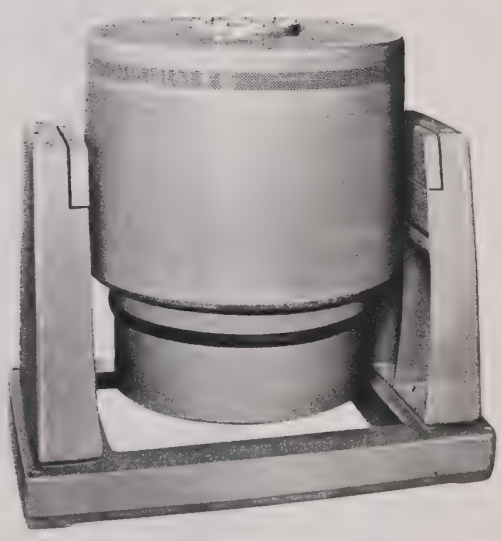
**Body Dia:**
11 - 3/4"

**Max Output:**
500 lbs pk force
1 inch pk-pk stroke

**Cooling:**
Air/Water

**Armature Type:**
Wound Coil

**Body Dia:**
17"



**Max Output:**
4000 lbs pk force
1 inch pk-pk stroke

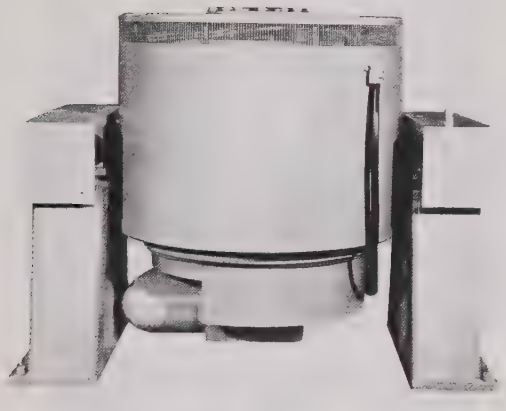
**Cooling:**
Air

**Armature Type:**
Wound Coil

**Body Dia:**
27 - 1/2"

# SHAKERS

All U-D shakers utilize **air cooled armatures** for maximum reliability. Many models are available with the unique INDUCT-A-RING armature, further described on page 6.

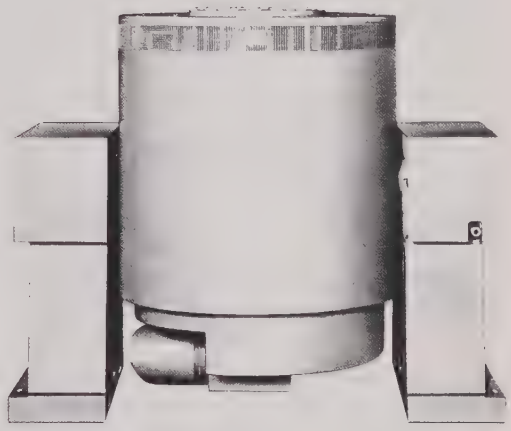


**Max Output:**
7000 lbs pk force
1 inch pk-pk stroke

**Cooling:**
Air

**Armature Type:**
Wound Coil

**Body Dia:**
35″

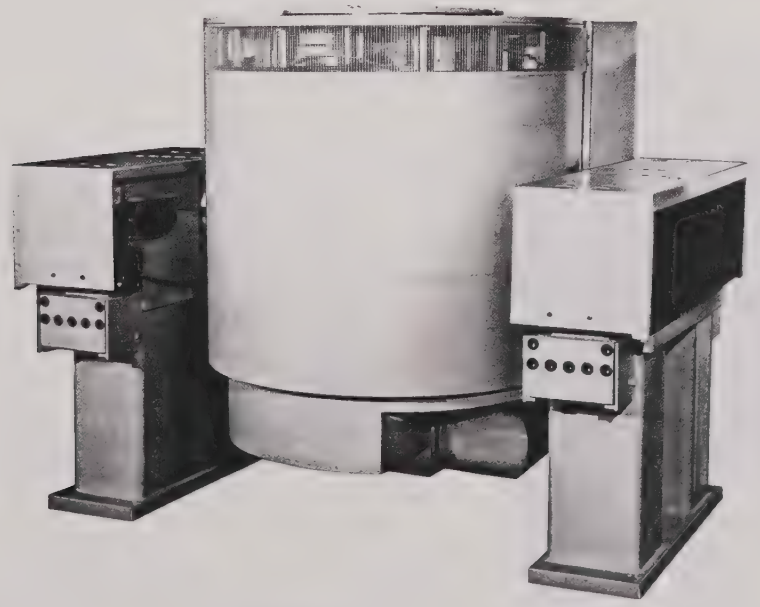


**Max Output:**
24,000 lbs pk force
1 inch pk-pk stroke

**Cooling:**
Air/Water

**Armature Type:**
Wound Coil (to 12,000 lbs)
INDUCT-A-RING (to 24,000 lbs)

**Body Dia:**
35″



**Max Output:**
40,000 lbs pk force
1 inch pk-pk stroke

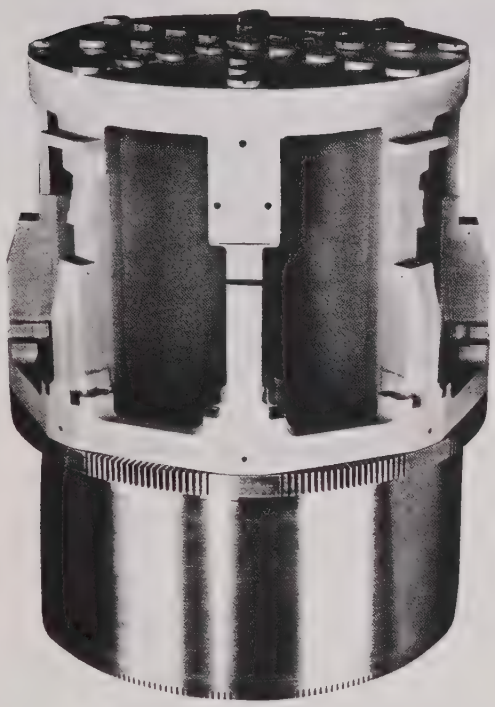
**Armature Type:**
INDUCT-A-RING

**Cooling:**
Air/Water

**Body Dia:**
44″

# INDUCT-A-RING ARMATURE

INDUCT-A-RING is the U-D trade name for a revolutionary armature design concept. The principle of transformer action is utilized to transfer energy from stationary AC driver coils (stators) to the armature.



The moving element is a simple two-piece metal structure. A single turn, solid metal cylinder is bolted directly to the shaker table casting, providing the ultimate in strength and rigidity.

All points on the vibrating member are at ground potential (zero voltage) at all times. There are no electrical windings with epoxy bonded joints. There is no possibility of voltage breakdown, and therefore no insulation is required.

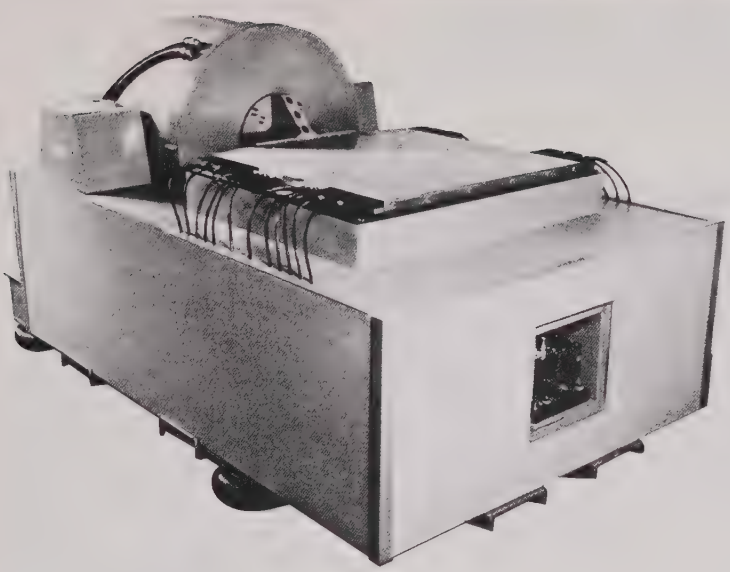
The solid metal, single turn ring is air cooled. Cooling connections subject to armature vibration are eliminated.

AC currents are induced into the solid metal ring, eliminating electrical connections which bridge stationary and moving parts.

The INDUCT-A-RING armature is featured in 1000IAR SERIES and 4000 SERIES shakers, rated up to 24,000 lbs force and 40,000 lbs force, respectively. A special high frequency 3000 lbs force configuration is also available, see below.

# HIGH FREQUENCY 208IAR

The Model 208IAR Shaker rated at 3000 pounds force utilizes a special "Induct-A-Ring" armature consisting of a one-piece continuous aluminum casting with an integral single-turn cylinder acting as the force generating coil (illustrated at the right). The 9¼ inch diameter table has an unloaded resonant frequency of 5,800 Hz making the 208IAR Shaker an excellent high frequency machine for use in testing turbine blades, engine accessories and related items. See above for additional discussion of the Induct-A-Ring concept.



# PERMALINE

## Combined Slip Table Assembly

The PERMALINE Combined Slip Table Assembly allows testing in three mutually perpendicular axes while using only one basic test fixture. Permanent factory alignment of the shaker and slip table provides quick changeover from vertical to horizontal operation. Inflatable air mounts effectively isolate the entire assembly from the supporting structure, thereby eliminating the need for special floor construction.

Heavy loads may be vibrated horizontally without external support.

Factory alignment of the shaker and slip table is maintained by the rigid common base.

The massive base is deep sectioned throughout its entire length, minimizing bending vibration responses.

An oil recirculation system is provided with multi-cylinder, constant-flow pumps to assure uniform oil distribution over the complete bearing surface.

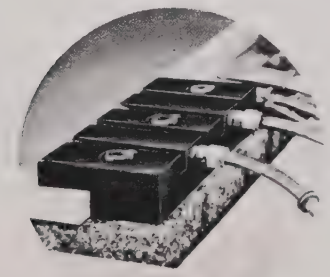
Quick-connect drive bar design permits vertical/horizontal mode conversion in less than ten minutes, utilizing a "bolt-from-the-top" slip plate attachment (see below).

The entire assembly is isolated from the floor by the heavy seismic mass supported on air mounts.

The CSTA requires no special floor construction, and may be moved from one area to another by a suitable forklift.

## 4HD HYDRAULIC BEARINGS

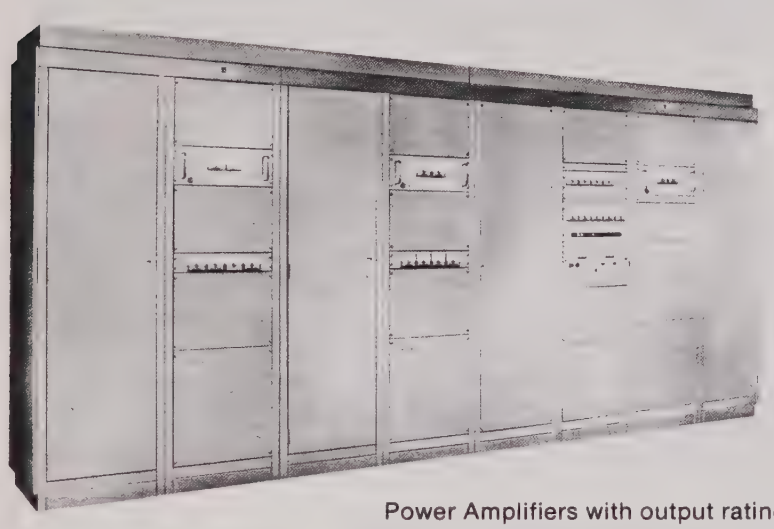
For large payload and/or high g level testing applications where substantial overturning moments are generated, hydraulic bearings are available to restrain lateral and vertical slip plate motion. One bearing is located at each corner of the slip plate, providing restraint at four widely spaced locations across the plate.



## QUICK-CONNECT DRIVE BAR

Fast, convenient conversion from vertical to horizontal mode operation is provided by a unique "bolt-from-the-top" drive bar design. Total conversion time is typically less than ten minutes including attachment of the drive bar to the armature, manual rotation of trunnions, and attachment of the slip plate to the drive bar using bolts totally accessible from above the plate, as shown below.

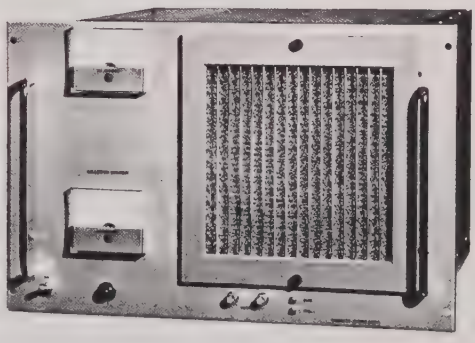
# SOLID STATE
## Power Amplifiers



U-D pioneered the use of large solid state power amplifiers to drive electrodynamic shakers in the early 1960's. Advances in silicon technology have been combined with proven circuit designs to produce the present generation of amplifiers. This design has demonstrated reliable performance in hundreds of customers installations since its introduction in 1968. Over eleven years of field proven reliability stand behind every U-D solid state power amplifier - a record unmatched in the industry.

Power Amplifiers with output ratings from 16 kVA to 256 kVA utilize a water cooled, modular output stage design with premium grade, silicon alloy junction transistors. Output transistors are stud mounted in massive water cooled heat sinks. All output transistor terminals are physically accessible, permitting routine maintenance checks during actual amplifier operation without draining of heat sink coolant and without the use of extender cards.

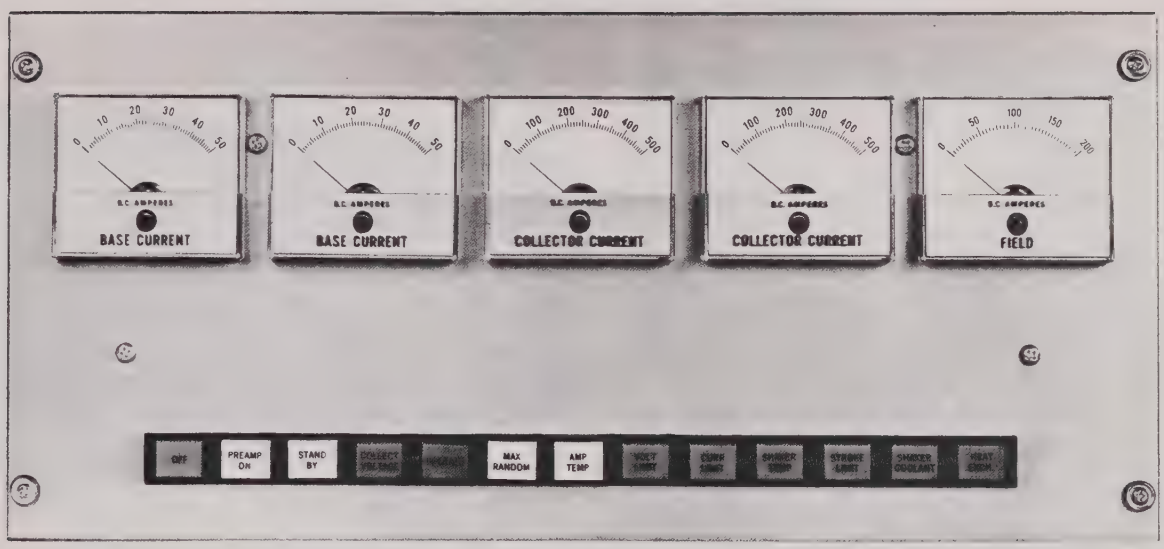
A number of lower force U-D shaker systems include the Model TA100A or Model TA250A Power Amplifiers rated at 1.5 kVA and 2.5 kVA, respectively. These models utilize the same basic circuitry as their water cooled counterparts except that output heat sinks are air cooled by an internal fan. Both the TA100A and TA250A are constructed in a rack mount chassis as illustrated at the right. An optional "current feedback" feature is available for "modal" testing to provide constant force operation (see page 12).



The Model TA30 and Model TA35 Power Amplifiers are air cooled, rack mount configurations rated at 250 VA each. The TA30 is typically used to drive the Model 5PM or Model 20 Shaker for general purpose testing. The TA35 typically is used to drive the Model 1 Shaker for "modal" testing applications (see page 12).

TA30

TA35




**System Control Panel (Typical)**

System pushbutton operating controls, output meters and diagnostic lights are consolidated on a central control panel which typically is located in the Power Amplifier console. An optional remote control panel is available to permit installation of duplicate system controls in a control console remote from the Power Amplifier.

# SRP-3 SPECIMEN PROTECTION

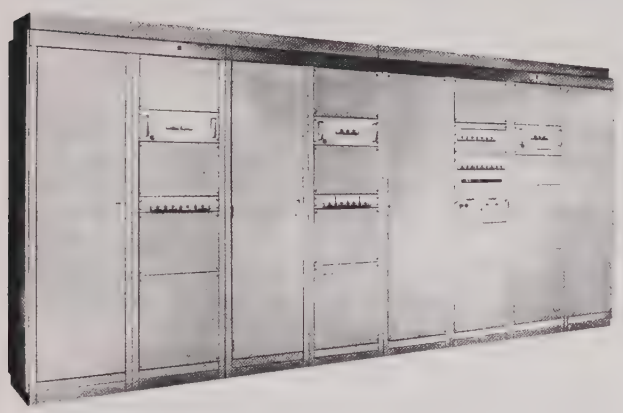
The Model SRP-3 SINE-RANDOM SPECIMEN PROTECTION SYSTEM incorporates a comprehensive, systems-integrated methodology (1) to provide an effective means of placing adjustable limits on the output capability of a high performance shaker system, and (2) to minimize potentially destructive acceleration transients which might otherwise be generated during conventional system shutdowns.

# DIGITAL CONTROLS INTERFACE

U-D guarantees the interface of its shaker systems with any digital control system. This guarantee assures our customers of complete flexibility to select the digital control configuration best suited for their requirements, without concern for interface compatibility.

U-D also offers interface accessories to permit microprocessor control of system operating modes, multiple shaker switching and other functions which may be sequenced automatically for unattended operation.

# SOLID STATE POWER AMPLIFIERS FOR EXISTING SHAKERS



C10 C60
C20 C90
C21 C126
C30 C150
C50 C210
C220

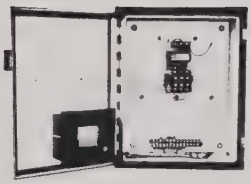
330 275
246 275A
300 335
A249

U-D offers a complete family of Solid State Power Amplifiers to replace high voltage vacuum tube P.A.'s in most older shaker systems as indicated on the right. Contact our factory for recommendations concerning your specific shaker model.

# CLOSED LOOP WATER COOLING ACCESSORIES

For those U-D Vibration Test Systems which require water cooling of the Power Amplifier and/or Shaker, complete closed-loop cooling consoles are available as illustrated on the right. The console, constructed in an attractive paneled enclosure, includes all the required heat exchanger hardware, pumps, filters, deionizers, conductivity monitoring and complete interlock wiring to assure fully systems-engineered operation.

Exposure of maintenance personnel to electrical shock hazard is minimized by the use of water tight conduits to remove all electrical terminations from console areas where water connections are located. Access to input power connections, control wiring and water conductivity monitor is provided within a NEMA 12 enclosure, as illustrated.

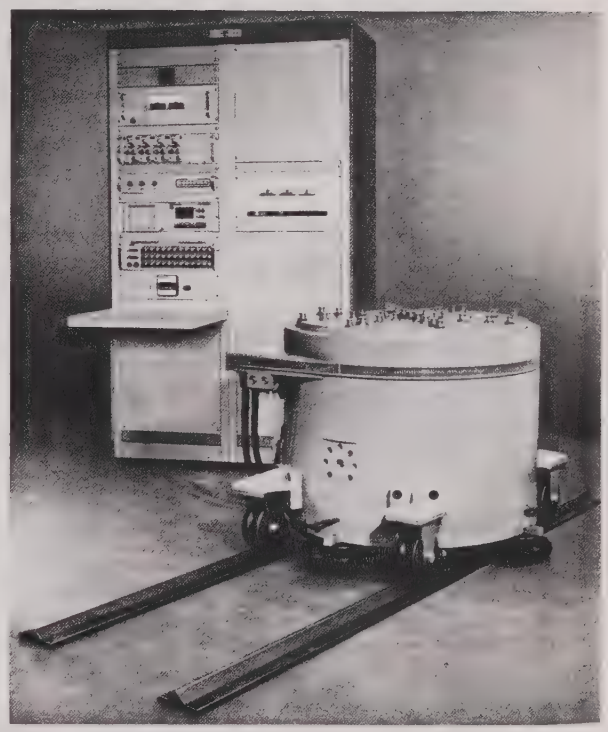


**NEMA 12 Enclosure**

**Separate Cooling Console (typical)**

# MIL-STD-781C/NAVMAT P-9492
## Products

U-D manufactures a number of shaker systems specifically designed to meet MIL-STD-781C, NAVMAT P-9492, and similar requirements for reliability and screening tests.



### RTS-5 SHAKER

The Model RTS-5 Shaker (pictured) is a husky, all air cooled machine providing a 31½ inch diameter table which can accommodate test loads up to 2000 pounds for vertical mode operation. Output ratings are available from 2800 pounds rms to 10,500 pounds rms random force depending upon the Solid State Power Amplifier supplied.

### V560 SHAKER

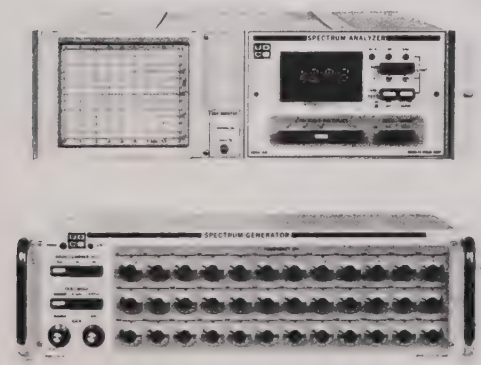
The Model V560 Shaker utilizes an integral 12 inch diameter table, plus a series of optional table expander accessories to accommodate larger payloads. The 12 inch table provides uniform vibration inputs to the test load up to 2000 Hz and higher. Table expanders with 16, 24 and 30 inch diameters are optionally available for large payload vertical testing, or a combined slip table assembly (CSTA) is available for horizontal mode operation (see page 7). Output ratings for the V560 range from 2000 pounds rms to 6000 pounds rms random force.

### AGREE CHAMBER INTERFACE

Both the RTS-5 and V560 Shakers are directly compatible with new or existing AGREE chambers. Optional V-groove casters and guide tracks for the RTS-5, or a separate pallet truck accessory for the V560 provide convenient positioning of the shaker relative to the chamber.

### RANDOM CONTROL ACCESSORIES

The Model SG-36 Spectrum Generator provides the drive signal to the power amplifier for random testing, utilizing a noise generator source and 36 equalizing filters. Each filter has an adjustable gain control which in combination cover the frequency range from 10 Hz to 2000 Hz. The SG-36 is used in "open loop" to manually shape the acceleration PSD versus frequency profile. An internal compressor circuit provides transient-free initiation and termination of the vibration test.




The Model A-36 Spectrum Analyzer has 36 filters which analyze the accelerometer response signal and drive a CRT display showing the complete 10-2000 Hz spectrum. A true rms digital meter indicates the overall g rms level including adjustable HIGH/LOW test limits which automatically trigger the SG-36 compressor if the test level does not remain within the selected "window." Simple pushbutton controls permit initiation and termination of the test. Capability for remote sequencing by a chamber microprocessor is provided.

### SINE CONTROLS

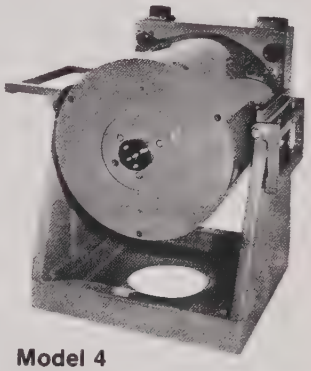
Automatic controls for swept sine vibration tests are also available, as summarized on page 13.

# MODAL SHAKER SYSTEMS

Unholtz-Dickie manufactures a family of shakers designed specifically for "modal" testing. These shakers feature long stroke, low internal damping, and near zero axial spring rate. These special characteristics facilitate the excitation of pure structural modes, especially when multiple shaker arrays are utilized. The shaker moving element includes a hardened output shaft for connection to the test object.

These modal shakers incorporate a double ended field structure, providing parallel flux paths from above and below the magnetic air gap. This design gives maximum magnetic flux linkage with the armature coil, and assures optimum waveform purity. Uniform flux density throughout the operating stroke provides output force proportional to armature current, independent of armature position.

When driving power is provided by a U-D solid state power amplifier with "current feedback," these shakers can be operated as **constant force** generators. In this operating mode, shaker armature current is proportional to power amplifier input voltage through large variations of load impedance; therefore, the magnitude of the generated AC force in the armature coil remains constant as a function of frequency. This constant force characteristic also requires the shaker to have a "force/armature current" ratio reasonably independent of armature position, as described earlier. Constant force sweeps can be performed without force links, external servos, or tracking filters.



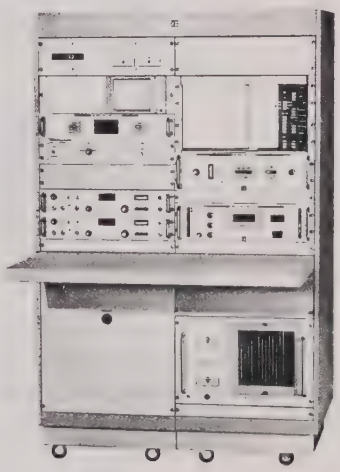
Model 4

Three basic models are available. The Model 1 is a 50 pound force, permanent magnet design with a one inch stroke. The Model 4 is a four inch stroke shaker rated up to 250 pounds force. Both of these units feature folding-type carrying handles which enhance portability.

The Model 6 Shaker generates up to 1000 pounds force and provides a full six inch stroke. This shaker is frequently used to generate low frequency motion in seismic simulation studies, or for vehicular studies in aerospace applications.

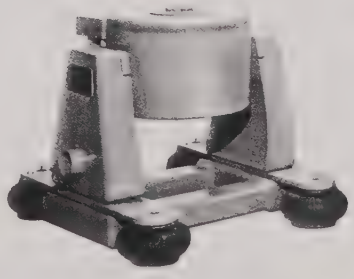
## SERIES 300 VIBRATION TRANSDUCER CALIBRATION SYSTEMS

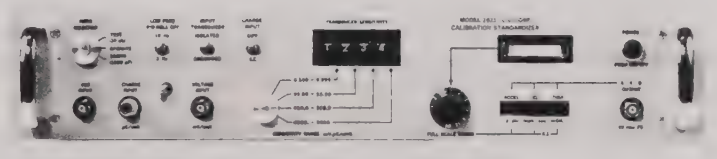
The Series 300 Calibration Systems are offered with manual controls for point by point calibration, or with frequency sweeping controls giving an automatically drawn curve of % deviation of the "unknown" transducer sensitivity relative to the "reference" accelerometer, as a function of frequency. Original data is permanently plotted, eliminating operator errors in readout and transcription.



Model 351 System

At full system performance, and with automatic servo controls operating, acceleration waveform distortion is less than 1.5% at all operating frequencies. The overall system noise level is less than .005 g rms. Automatic plotting systems feature 0.25% plotting resolution of the unknown transducer output relative to the reference.





The Model 1611 Precision Charge/Voltage Calibration Standardizer is supplied in 300 Series Calibration Systems to provide stable, high accuracy comparison calibrations. Typical overall instrument accuracy and stability is ¼%, with flat response from 2 to 20,000 Hz.

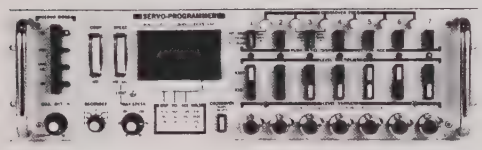
# AUTOMATIC SINE CONTROLS

U-D manufactures a variety of general purpose and specialized automatic sine control systems, including the two popular configurations shown below. Both of these control systems feature a **zero static error servo**, permitting large gain changes in the compressor (AGC) circuitry without introducing static errors in the actual control level.

The **OSP-4 Oscillator-Servo-Programmer** is our most economical, compact sine control system. This unit combines the following features in a single chassis: a sweeping digital sine generator, frequency counter, vibration meter, servo control, four-level programmer, and input charge amplifier. Frequency range: 5 to 5,000 Hz.

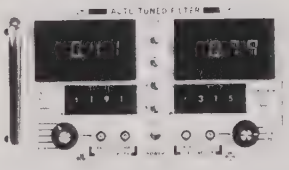
The most comprehensive sine control system available in the industry consists of the **OSC-1S Sweep Sine Generator** and **SPA-7 Servo Programmer.**

The OSC-1S is a sweeping digital sine generator which operates from 2 to 5,000 Hz. A built-in digital frequency counter reads and displays ten times per second even at 2 Hz. Sweep rate and number of sweeps may be preselected to provide automatic test shutdown. A sawtooth generator output permits synchronous scope display of the vibration waveform.



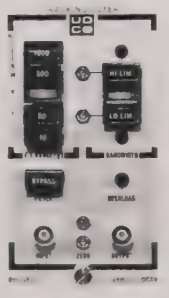
The SPA-7 is a programmable seven-level servo. Digital display of acceleration, velocity or displacement is provided, plus automatic or manual modes for selecting the crossover frequency between program segments. An input charge amplifier is standard.

# ENGINE TEST CELL MONITORING



The Model ATF-4A Auto-Tuned Filter is designed to measure narrowband and wideband vibration components in a variety of engine test cell applications including aircraft turbofans and other engines. The ATF-4A is a four channel instrument, each channel containing two automatically tuned constant percentage bandwidth filters. Each data channel accepts a conditioned velocity signal such as from the U-D Model 1612Charge Amplifier and provides DC outputs proportional to the two narrowband vibration levels. The wideband level also may be selected. The center frequencies of the two narrowband filters are controlled by conventional tachometer signals from the engine (N1 and N2), and the tachometer frequency ratios are widely adjustable from the front panel.

# TRACKING FILTERS

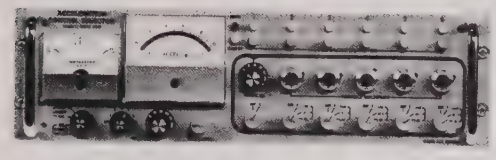


The Model TF22 Tracking Filter is a unity gain, constant percentage bandwidth filter featuring stable integrated circuit design. The filter bandwidth varies between 2 and 200 Hz as defined by 10% of the tuning frequency. Fixed bandwidth operation also is selectable.

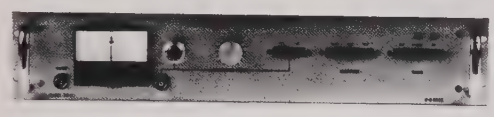
The TF22 typically is used to filter noise and harmonic distortion from the control signal in swept sine vibration tests. A log DC signal proportional to the filtered AC output is provided, facilitating mechanical impedance measurements and transfer function analysis. Six TF22 modules can be mounted in a 5¼ x 19 inch rack space.

# CONTROL ACCESSORIES

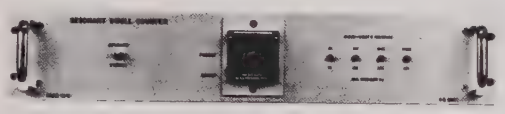
Model MAC-8 Multifunction Averaging Control accepts up to eight 10 mV/g signals for controlling to the average signal level. Can be used for sine or random vibration testing.



Model ACS-6 Acceleration Control Selector automatically selects for feedback control the highest (or lowest) acceleration input from up to six 10 mV/g sine acceleration signals, by gating to the output whichever signal reaches its preset amplitude limit.



Model RD-1 Resonant Dwell Control automatically maintains the vibration testing frequency at the resonant frequency of a test specimen during fatigue testing.



Model RD-2 Resonant Dwell Counter indicates the number of stress cycles accumulated by a specimen undergoing a resonant dwell test. Counter may be preset to initiate automatic shutdown after completion of desired number of stress cycles.

Model AM-123 Vibration Monitor/Limiter provides overtest protection for vibration test specimens, utilizing adjustable, simultaneously active shutdown limits for both acceleration and displacement. Protection circuits operate for sine or random testing and provide soft, rapid shutdown.

# VIBRATION MONITORING ACCESSORIES

Model 1610M Portable Vibration Monitor can be used to condition piezoelectric accelerometers with 0.5 to 100 pC/g sensitivity. Monitors acceleration, velocity, or displacement with log scale meter readout and switch selectable outputs. Also available in single and dual channel rack mount versions (1610RM, 2610RM).

The Model 122P Charge Amplifier provides front panel selection of normalized output signal sensitivity from .01 to 10 V/g in 1, 3, 10 steps, thereby optimizing feedback signal level requirements commonly encountered when interfacing with digital control systems. The 122P includes 1-100 pC/g Dial-A-Gain input sensitivity adjustment, operation with remote preamps, and plug-in low pass filtering.

Model SA22 Shock Charge Amplifier measures shock pulse durations from 100 microseconds to 500 milliseconds and pulse amplitudes up to 100,000 pC peak. Intended for use with customer-supplied storage scope and camera.

Model 2216 Signal Conditioner is a low cost, modular instrument for use with the Model 100PA or 1000PA Accelerometers. Permits acceleration measurements down to 0.1 Hz with less than 30 micro "g" residual noise with the Model 1000PA or measurements down to 0.5 Hz with less than 50 micro "g" residual noise with the Model 100PA.

# D22 SERIES SIGNAL CONDITIONERS

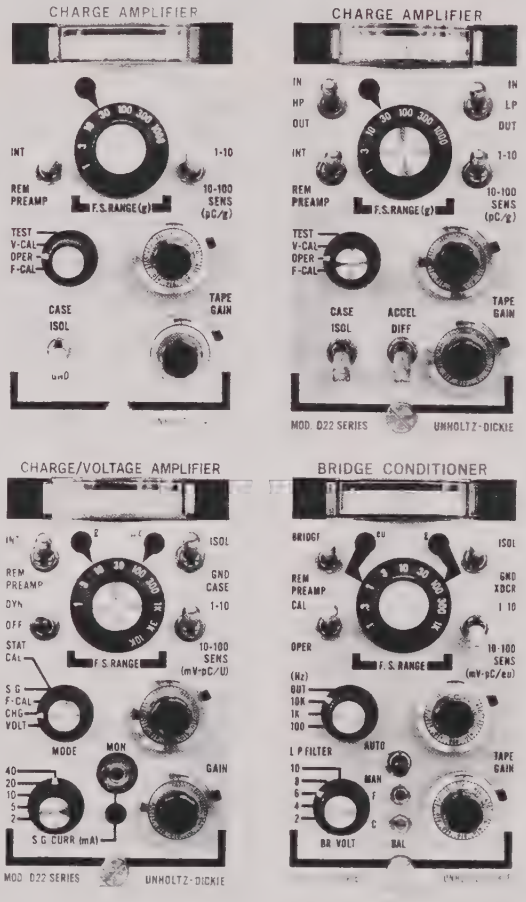
D22 Series Signal Conditioners feature integrated circuit design with superior low noise operation, DIAL-A-GAIN input sensitivity adjustment and rugged, modular construction. Four basic models are offered: D22PM, D22PMH, D22PMR, and D22PMB as illustrated below. A variety of optional features are available to satisfy most types of data acquisition requirements.

### D22PM:

Accepts inputs from single-ended piezoelectric accelerometers (0.5-100 pC/g) or can be used with 22CA-2 Remote Preamps. Includes output meter, adjustable 0-10 V pk full scale output, isolate/ground feature for rejection of ground loop pickup, and 3 calibration modes.

### D22PMR:

Accepts inputs from single-ended piezoelectric accelerometers (0.5-100 pC/g) and single-ended strain gages (for dynamic measurements), high impedance voltage sources, or can be used with 22CA-2 Remote Preamps. Includes calibrated constant current strain gage supply, output meter, adjustable 0-1 V pk full scale output, isolate/ground feature for rejection of ground loop pickup, and 2 dynamic calibration modes.




### D22PMH:

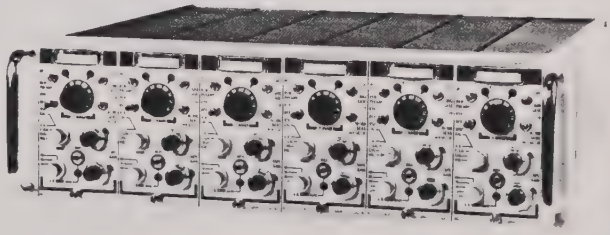
Accepts inputs from single-ended and differential (high temp) piezoelectric accelerometers (0.5-100 pC/g) or can be used with 22CA-2 Remote Preamps. Includes switch selectable Low Pass and High Pass filters, output meter, adjustable 0-10 V pk full scale output, isolate/ground feature for rejection of ground loop pickup, and 3 calibration modes.

### D22PMB:

Accepts differential inputs from 1, 2 or 4 arm bridges (for dynamic or DC strain measurements) and piezoresistive accelerometers, or can be used with 22CA-2 Remote Preamps. Includes selectable precision bridge power supplies, selectable Low Pass filter, auto balance feature, output meter, 0-10 V pk full scale output, and isolate/ground feature.

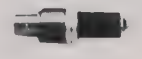
## D22 OPTIONS

| DESCRIPTION | SUFFIX |
|---|---|
| 10 mV/g servo output | S |
| 1, 10, 100 mV/g servo output, selectable | J |
| 100 mV-sec/in velocity output | I |
| 1 V/in displacement (DA) output | II |
| Linear DC output, 10 V F.S. | F |
| Log DC output, 1V/decade | L |
| ±100 mA galvo output | G |
| ±100 mA line driver (boosts tape output) | C |
| Internal cal. oscillator | O |
| Tracking filter interconnection | T |
| 0.5 Hz frequency response | -2 |
| Extra X10 gain | -3 |
| Remote relay cal. | -4 |
| Large 2½" scale meter | -8 |
| External range control | E |
| Auto ranging | A |



Model 22RA Rack Adapter accepts six D22 Series modules with standard 5¼ inch panel height. Also accepts six TF22 Tracking Filter modules (see page 13).

Models D22PM, D22PMH and D22PMR are available with the "-8" option which provides a 2½ inch scale meter for easier readout. A special 8¾" high rack adapter (22RA-8) is available for rack mounting -8 type modules.



The Model RCA-2TR Remote Charge Preamp may be used with any of the D22 Series instruments shown above and is a companion unit to the Model P22MS at left, which operates exclusively with the remote charge preamp.

# ACCELEROMETERS

A full line of self-generating piezoelectric accelerometers are manufactured by Unholtz-Dickie for general purpose vibration testing and for many special measurement requirements. Various models are optimized to provide features such as subminiature size, high output sensitivity, and high temperature operation.

### 10B10 and 10B10T:

These two models have a factory adjusted sensitivity of 10 pC/g. This normalized output feature permits the interchange of accelerometers among many channels of charge amps without concern for changing input sensitivity settings. Such an arrangement eliminates a common source of instrumentation errors.

### INTEGRAL ELECTRONICS ACCELEROMETERS

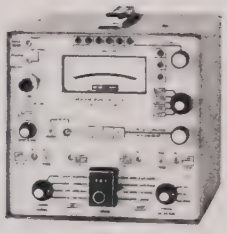
The Model 100PA (100 mV/g) and 1000PA (1000 mV/g) are high sensitivity, low output impedance accelerometers that are particularly well suited for wide dynamic range acceleration measurements and reliable, low level displacement measurements requiring double integration. The 100PA is typically used with the 1610M, 1710M and 2216 Signal Conditioners for measurements down to 1 Hz. The 1000PA provides flat response down to 0.1 Hz with residual noise $\leq$30 micro g when used with the Model 2216 Signal Conditioner.

# INDUSTRIAL VIBRATION MONITORING

The Model 8803 Industrial Accelerometer and companion 800 Series Vibration Monitor constitute a unique sensor/instrument system for rotating machinery monitoring and protection. The low output impedance 8803 Accelerometer features simple installation and a rugged two-wire cable. A variety of 800 Series modules are available, including the 841B which takes unique advantage of the TOTAL vibration spectrum by simultaneously measuring low frequency displacement, mid-band velocity, and high frequency acceleration. Individually adjustable alarm functions for each vibration parameter are provided. This technique utilizes information which is essentially ignored by proximity probes and velocity pickups.

The **Model 1602 Transducer Tester** is a fixed frequency, portable test stand which may be used to verify the operation of any vibration transducer. An internal reference accelerometer is utilized to monitor actual test table motion, which is displayed in terms of acceleration, velocity, or displacement on a convenient digital readout. 50 Hz and 100 Hz models are available.

The Model 1710M Vibration Monitor/Analyzer provides a comprehensive capability for measurement and analysis of rotating machinery vibration. When used with the Model 100PA Accelerometer, the 1710M permits wide dynamic range acceleration measurements and excellent low level, low frequency displacement measurements.



A manually tunable 10% bandwidth filter permits identification of specific vibration conditions over the 1 Hz to 10,000 Hz frequency range. Selectable 100 Hz HP filtering of velocity and 1000 Hz HP filtering of acceleration provide a particularly effective means of logging machinery midband and highband vibration characteristics. A unique "wear" feature provides for relative measurement of the severity of impact type vibration indicative of bearing wear, gear wear, rubbing, loose parts, or cavitation.

**6 Brookside Drive • Wallingford, Connecticut • 06492**

**(203) 265-3929**

Printed in U.S.A.

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
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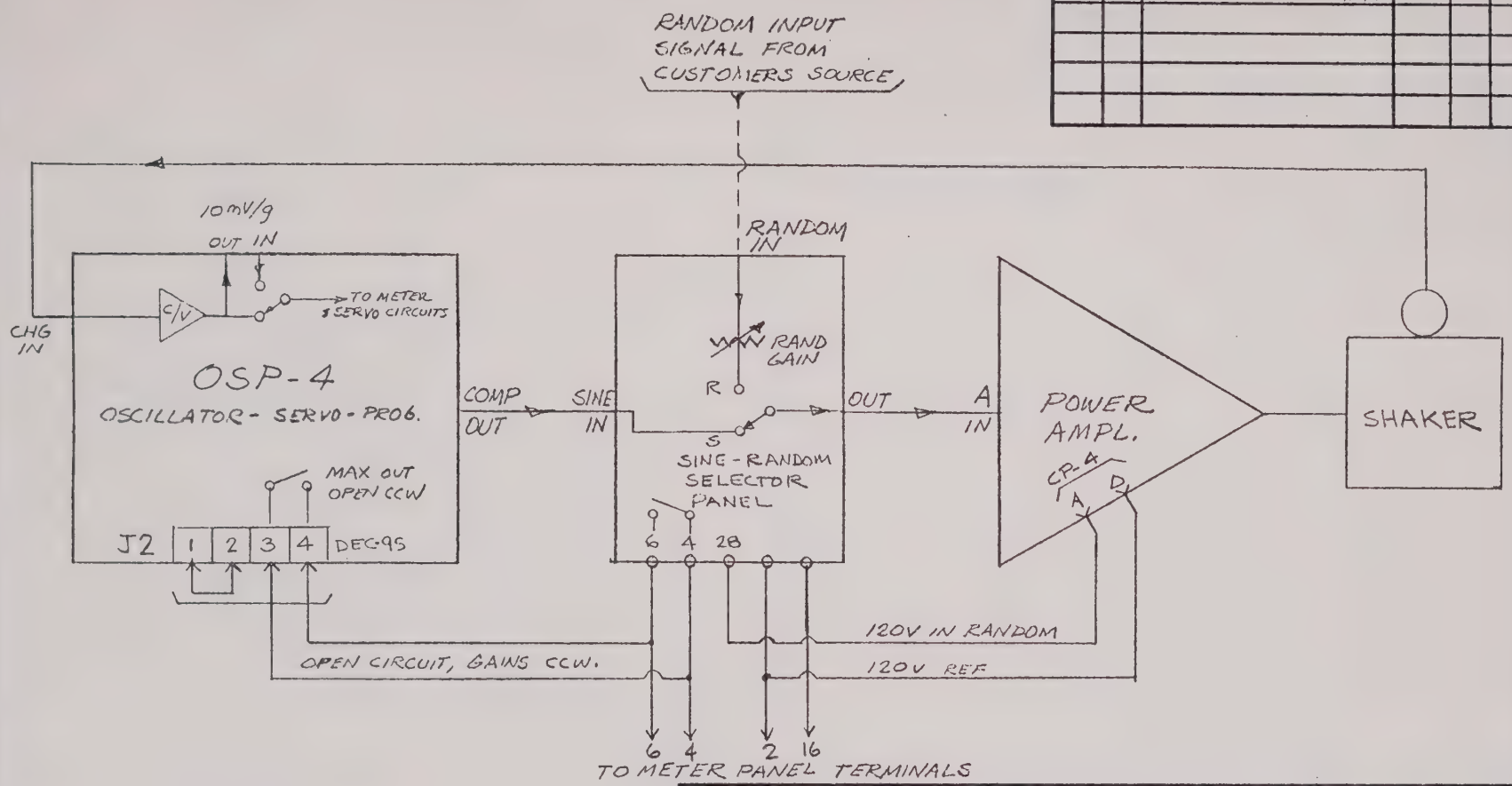


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|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ - DICKIE CORP. | | |
| DECIMAL ± | OSP-4, RAND GAIN S-R SELECTOR | SCALE | DRAWN BY SCB |
| | | | APPROVED BY |
| FRACTIONAL ± | TITLE: INSTRUMENT INTERCONNECTIONS | | |
| ANGULAR ± | DATE: 1-18-82 | DRAWING NUMBER: A15828A | |

K&E ALBANENE ® 10 5465 ENGINEERS' STANDARD FORM

MADE IN U.S.A.

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
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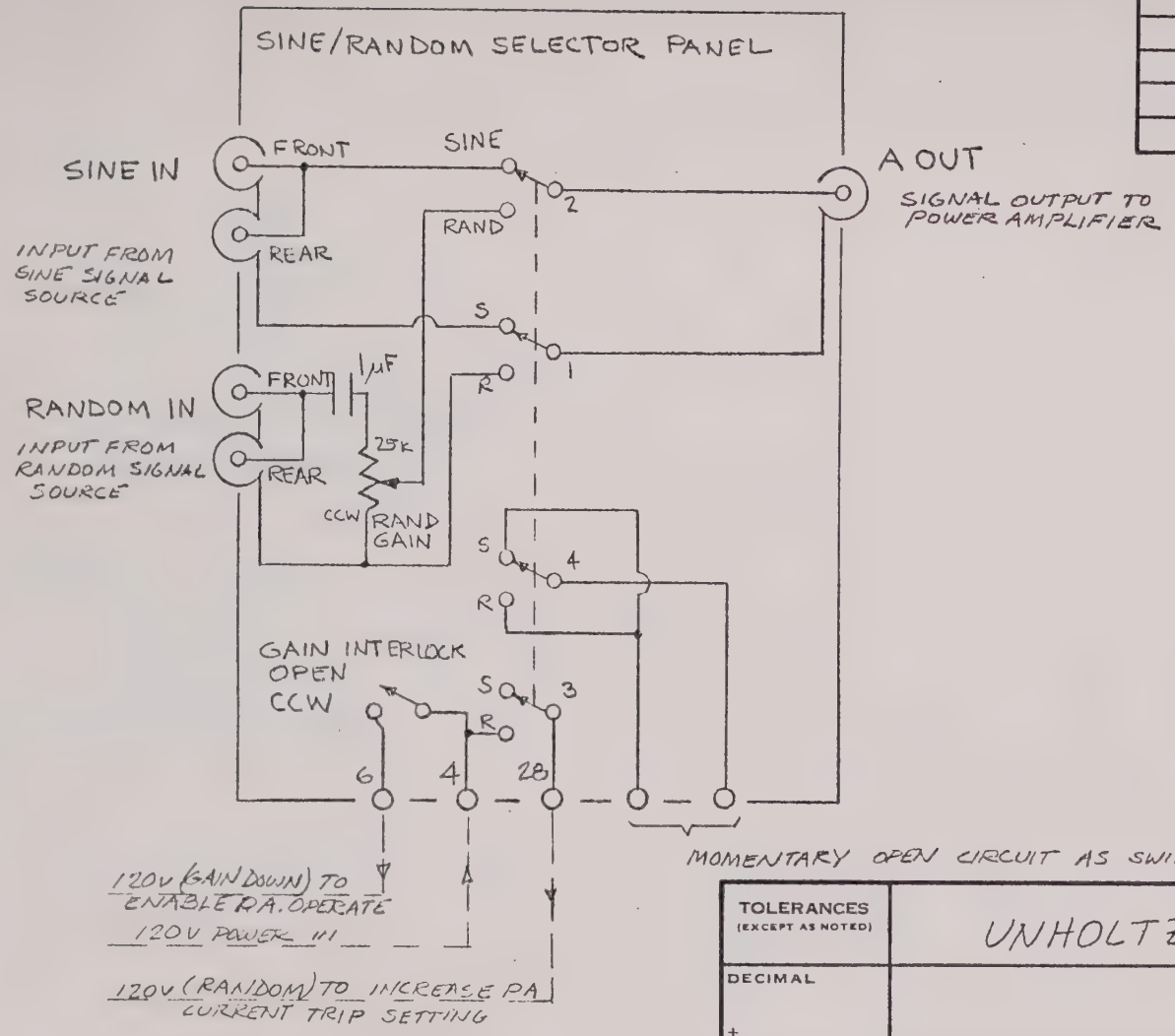


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|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORP. | | |
| DECIMAL ± | | SCALE | DRAWN BY / APPROVED BY |
| FRACTIONAL ± | TITLE SCHEMATIC SINE/RANDOM SELECTOR PANEL, RANDOM GAIN | | |
| ANGULAR ± | DATE 1-19-82 | DRAWING NUMBER A15830 | |

K·E ALBANENE ® 10 5465 ENGINEERS' STANDARD FORM

MADE IN U.S.A.

| DATE | SYM | REVISION RECORD | AUTH. | DR. | CK. |
|---|---|---|---|---|---|
| 8/79 | A | Sol Valve Options | JAT | | |
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CUSTOMER: TRW, LA JOLLA, CA

SYSTEM NO.: TA250-102

Date: 10/13/82

Cables:

35' P.A. to Blower

20' P.A. to Shaker

~~P.A. to CSTA Oil Pump~~

~~P.A. to H.E.~~

or P.A. to Sol. Valve (TA145 and up) 25'

~~P.A. to Remote Control~~

~~Shaker to Sol. Valve~~

Hoses:

~~P.A. to H.E.~~

or P.A. to Sol. Valve/to Filter 25'

~~Shaker to H.E.~~

~~or Shaker to Filter~~

Duct: Shaker to Blower 20' of 3"

Reference B15769A

| | | | |
|---|---|---|---|
| TOLERANCES (EXCEPT AS NOTED) | UNHOLTZ-DICKIE CORPORATION | | |
| DECIMAL ± | | SCALE | DRAWN BY Sys. |
| | | | APPROVED BY JAT |
| FRACTIONAL ± | TITLE CABLE & HOSE LENGTHS | | |
| ANGULAR ± | DATE 12/8/78 | DRAWING NUMBER ~ ~ A17722A | |

K&E ALBANENE ® 10 5465 ENGINEERS' STANDARD FORM

MADE IN U.S.A.

MP MASTER
MA34568